The AMSAT Journal

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Editor: John Hansen, WA0PTV
Editorial Staff: Ron Long, W8GUS
Walter Daniel, KE3HP, Buzz Gorsky, WH6I

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AMSAT
25 Years
In Space
1969 - 1994

Radio Amateur Satellite Corporation (AMSAT) Celebrates 25th Anniversary

This issue of the AMSAT Journal marks the 25th anniversary of the founding of the Radio Amateur Satellite Corporation (AMSAT) - a scientific, educational 501(c)(3) corporation devoted to providing satellites for the Amateur Service and disbursing information on how to use them to hams all over the world.

Throughout this Jubilee year we will be highlighting the history of AMSAT and the individuals and accomplishments that have resulted in amateurs world-wide having access to over a dozen orbiting communications satellites. This month we feature retrospectives by the first President of AMSAT, Perry Klein, W3PK and it's most recent, Bill Tynan, W3XO.

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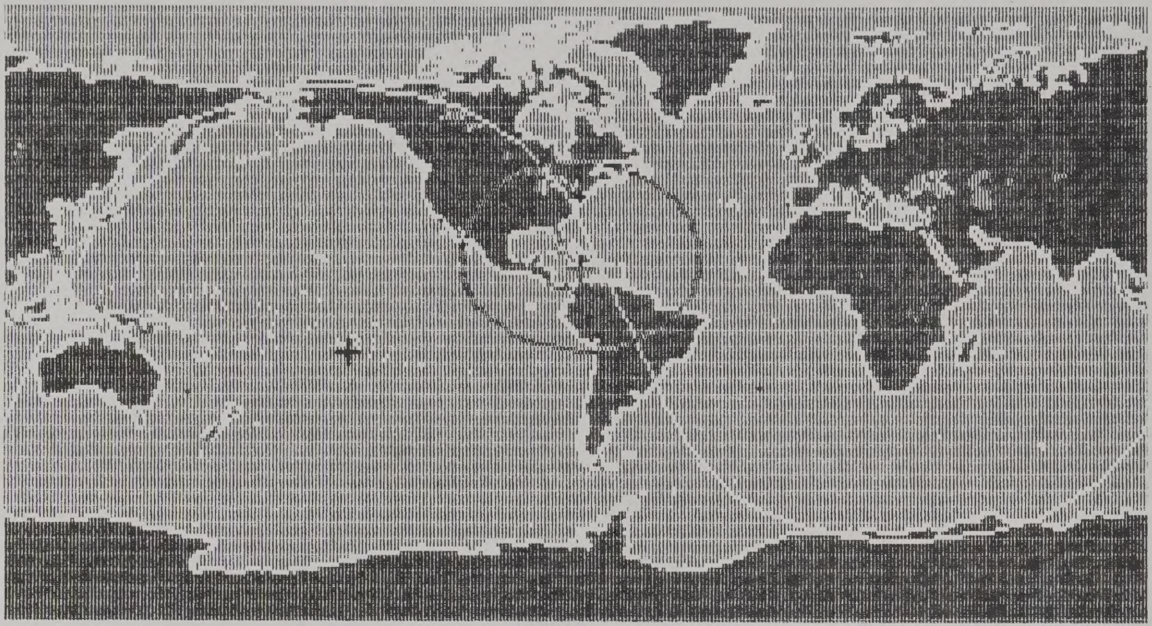

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***Editorial Office:* John A. Hansen, WA0PTV, 49 Maple Avenue, Fredonia, NY 14063. Internet: wa0ptv@amsat.org, Compuserve: 70353,460.**

Production Office: Executive Printing Services, Inc. 6640 Ammendale Road, Beltsville, MD 20705.

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The AMSAT Journal staff is always interested in article submissions. Whenever possible, text should be on IBM or Macintosh compatible diskette (3 1/2 inch preferable) with hard copy. AMSAT-NA reserves the right to select material for *The AMSAT Journal* based on suitability of content and space considerations. The editors of this publication are volunteers giving freely of their talents, time, and efforts to produce *The AMSAT Journal*.

Apogee View

The Beginning

by Bill Tynan, W3XO

I have always considered it important for everyone to know something about the history of their society. We should all be familiar with the history of our nation as well as our particular ethnic and religious origin. Similarly, a doctor or lawyer should know something of the trials and tribulations their professions went through in evolving to their current states. Radio amateurs should be acquainted with the early days of wireless and how amateur radio became established as a defined and accepted radio service. There was a time when there was a question as to whether or not such a thing as "amateur radio" would exist at all.

Since our specific interest is amateur satellites, we should be familiar with how they got started and of the contributions various people made to them through the years. By such knowledge, we can better appreciate what we have today. Such knowledge will also be invaluable in helping us plan what we want to have available tomorrow.

Although AMSAT is celebrating its 25th birthday this year, the beginning of the amateur space program actually goes back more than 30 years with the successes of Project OSCAR. Not only did these pioneers provide inspiration for what came later, but they showed that amateur satellites could be built on a "shoestring" and, once built, that launches could actually be found for them.

The actual beginning of AMSAT can be traced to early in 1969. The inspiration for the organization was provided by George Jacobs W3ASK, who still writes the propagation column for CQ Magazine. On January 9, of that year, George was the guest speaker at the COMSAT Amateur Radio Club. In his talk he recounted the accomplishments of Project OSCAR and said that there was no reason why a similar effort could not be mounted on the East Coast. He noted the space and technical expertise that had been assembled in the Washington, DC area alone.

George's talk was particularly inspiring to a young Ph.D. who worked at COMSAT and was an active member of the Club - one Perry I. Klein K3JTE (now W3PK). Perry vowed to accept George's challenge. and immediately set to work on the project.

I first became aware of these activities one evening in late January when my phone rang. It was Jim Puglise W3CBJ (now K9CQ), then a co-worker of mine at the Johns Hopkins Applied Physics Laboratory. Jim asked me if I was acquainted with "Oscar East". My immediate response was; "Who's he?" He said, "no, it's not a person but some kind of amateur satellite organization that's getting started". He told me that there was to be a meeting that evening about it, and suggested that we go see what it was all about. We found the location, a modern apartment building in the newly rebuilt Southwest section of Washington. Upon entering and introducing ourselves, we were seated with perhaps a dozen people, all associated with amateur radio clubs at various research labs and other technical organizations around the DC area. I do not recall all of those present, but I will attempt to name a few. Of course, there was Perry, whose apartment it was. Also in the group, were two people from Goddard Space Flight Center. One was Harry Helfrich W3DWF (later W3ZM, a call which AMSAT still holds as a memorial to his very significant contributions to the fledgling organization). The other was newly arrived from the University of Michigan - a not yet 22 year old young man named Jan King K8VTR (now W3GEY). I do not recall whether or not Dick Daniels WA4DGU (now W4PUJ) was present at that particular meeting, but he was in on the early formative days of AMSAT.

Perry opened the meeting by outlining his concept for an organization to carry on in the work of Project OSCAR, and recounted what George Jacobs had said at the COMSAT Club a few weeks earlier. He announced his intention to form an organization built around people from the amateur radio clubs associated with various technical organizations. The group would exist to build amateur radio satellites and find launches for them.

All in attendance were inspired, largely due to the infectious enthusiasm radiated by Perry Klein and the excitement of doing something in space that would benefit Amateur Radio. However, all could readily see that we were committing ourselves to something that would represent years of hard work - work that promised to consume a large percentage of our lives and prevent us from pursuing other interesting activities. That premonition has certainly been born out for many of those original founders and numerous others who have stepped up in later years and volunteered their services to the amateur space program.

Following the first meeting at Perry's apartment, there were many others at various locations around Washington, mostly at COMSAT Headquarters. In addition to the task of defining the organization's structure, framing By-Laws and establishing a charter, we began to talk about technical projects we might undertake. As a part of this, we established study assignments. Among these were the feasibility of using gravity gradient stabilization, potential launch vehicles and how we might interface to them, suitable antenna and transponder designs, choice of frequencies, appropriate orbits and various power systems. Included in that item, in addition to solar arrays, was the possible use of nuclear isotope power supplies. Since JHU/APL, where I worked, had done early work in both gravity gradient stabilization and nuclear isotope power systems for space applications, I drew the assignment to collect information on these two technologies. It is interesting to note that the subject of spacecraft and ground support computers was not even on the list. Computers had not yet reached the stage where any of us had even considered putting one in an amateur satellite!

When we convened to report our findings on these fascinating subjects, George Jacobs was on hand once again - this time to nudge the organization he had inspired back on track. He noted that our studies were all well and good but didn't we think that it would be better to start with something relatively simple - something with which we could build confidence in ourselves and establish a reputation as a group that can actually get things done - not merely produce reports (a syndrome all too common in our Nation's Capital). He reminded us that there was an amateur satellite already built. It had been constructed by students at the University of Melbourne in Australia and sent, several years earlier, to Project OSCAR in hopes of an eventual launch. He suggested that obtaining a launch for this satellite and preparing it for its ride into space, might be a good first project for our new organization, which by then had been named the Radio Amateur Satellite Corporation, or AMSAT for short, with Perry Klein as its first President.

Foreground, AUSTRALIS - OSCAR 5.
Standing L to R, Jim Puglise W3CBJ, George Kinal K2MBU, Cap Petry W3AWN, Charles Dorian W3JPT, Bill Tynan W3KMV, Jan King K8VTR, Perry Klein K3JTE

The wisdom of George's recommendation was apparent to all of us, who by then numbered about fifty, and we immediately began work. We contacted Project OSCAR and the Australians who had built the spacecraft, later to be known as Australis OSCAR 5, or AO-5. All were eager for us to try our hand on getting it launched; and it was soon shipped to us. Even though it required a lot of work to get the satellite ready for launch and extensive negotiations with NASA to obtain a launch, AO-5 was successfully put into orbit January 23, 1970, just a year from that first meeting at Perry Klein's apartment.

While some of us were concentrating on securing a launch and putting Australis through the necessary environmental tests, activities for which Harry Helfrich was invaluable, others were working on letting the amateur community know what we were trying to accomplish. As part of this effort, Perry and I co-wrote an article for QST announcing the formation of AMSAT and outlining its goals. This article appeared in the June 1969 issue. It might be interesting to quote from the first few paragraphs, as I believe you will agree that the fantasy that Perry and I conjured up, 25 years ago, has largely come to pass.

"It's a chilly winter evening and darkness has fallen. The last remnants of 20 meter signals are just going out as you bid 73 to your friend Joe across the country. You have been keeping weekly skeds with Joe since he left the area, two years ago. It's sure nice to be able to keep in touch with him. "Twenty is about out", you say to yourself as you switch the receiver down to 40. Mostly foreign broadcast stations, a few amateur signals sandwiched in between; no clear spots and no CQ's can be heard. What's going on down on 75? A quick listen reveals the usual gang on 3999. Everything is pretty jammed up there too. You start to pull the big switch and go in and watch TV with the XYL when you remember. A few flicks of switches later you're tuning 2 meters. There are a number of weak but readable signals. That accent sounds like a VK! You wait for him to sign. Sure enough, he's working a JA. The JA comes back on the same frequency. He's not as strong as the VK but he's readable nevertheless. You tune around some more. There's a VE8 calling CQ. Imagine, 2 meter activity in such a location. His signal is not very strong but good and steady, not fluttery like stations from that area usually are on the HF bands."

The article goes on to say that this "fantasy" will become a reality if the new AMSAT group has anything to say about it. I think current AMSAT members will agree that turning on a 2 meter receiver and hearing hams from all over the world is not fantasy these days. That AMSAT group, and its brethren in many nations, have had a lot to say about it.

For those who would like to delve more into the history of the amateur space program, the aforementioned article and various other QST articles, dating from the early 1960s, provide an excellent chronicle. See also the other historical articles in this issue of the Journal and in other Journals throughout the remainder of this silver anniversary year. In addition, the Satellite Experimenter's Handbook by Martin Davidoff K2UBC, published by ARRL and available through the AMSAT office, contains a lot of information on the early days of both Project OSCAR and AMSAT. Of course, this book also includes a wealth of technical information on amateur satellites and their use.

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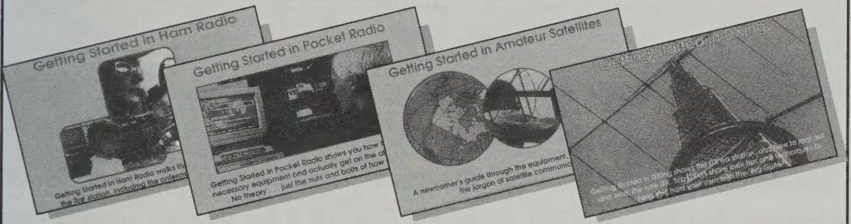

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The Formation and Early Days of AMSAT

by Perry Klein, W3PK

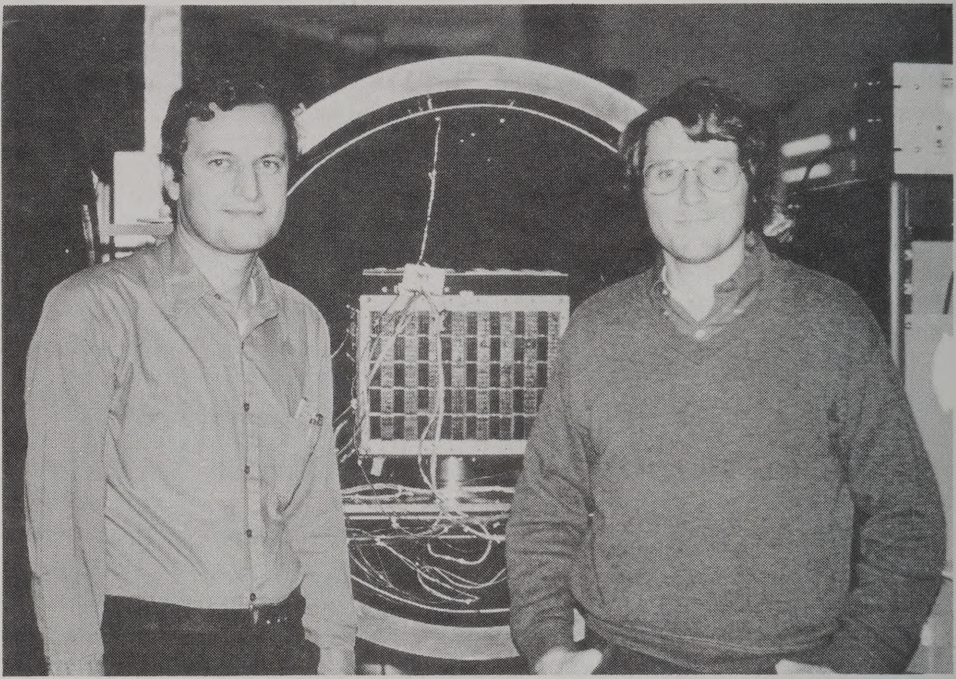
(Life Member No. 1)

One evening, back in early 1969, George Jacobs, W3ASK addressed the Communications Satellite Corporation (COMSAT) Amateur Radio Club in Washington, D.C., on the subject of amateur radio communications in space. George described the early history of the original OSCAR satellite program, beginning with OSCAR 1, launched in 1961, and continuing up to OSCAR 4, launched in 1965. He urged the COMSAT club to pick up where the original OSCAR group had left off, pointing out that with all the radio amateurs working in aerospace in the Washington area, the knowhow existed to continue the outstanding work of the California-based Project OSCAR Association.

George pointed out that two OSCAR packages were still in California, having never found a ride into space. One was a complete satellite built by the Project Australis group in Melbourne, Australia. The other was an in-band two-meter repeater developed by a group in Germany led by Karl Meinzer, DJ4ZC. A good start for a new "OSCAR-East" group would be to find rides into space for these two amateur satellite experiments.

We took George's suggestions seriously, and managed to assemble a group of Washington area hams, including Jan King, W3GEY and Harry Helfrich, W3ZM at the NASA Goddard Space Flight Center, Bill Tynan, W3XO and Jim Puglise, W3CBJ at the Johns Hopkins Applied Physics Laboratory, Cap Petry, W3AWN at Aeronautical Radio, Inc., and George Kinal, K2MBU at Computer Sciences Corp. Incidentally, Jan King was only 21 years old at the time; (I was 26.)

After several organizational meetings, the group incorporated as a non-profit organization in the District of Columbia on March 3, 1969 and AMSAT, the Radio Amateur Satellite Corporation was officially born. Dues were set at five dollars, and we all rushed to get our money in to get the first membership numbers. I remember that Jan didn't have any money with him, and had to settle with Member No. 6 when I lent him $5! Bill Tynan was a little upset, not getting a single-digit number. His was No. 10!



Perry Klein and Jan King W3GEY preparing OSCAR 8 for thermal vacuum testing, 1978

The group's first project was to represent the Project Australis group in securing a launch for their Australis-OSCAR satellite, which had been sitting in Lance Ginner's, K6GSJ's garage in California. When we received the spacecraft from Project OSCAR, I recall that we found spider webs inside among the hardware! We were able to obtain a donation of a new set of batteries for Australis-OSCAR (which had no solar cells), but one of the biggest challenges was to get NASA to agree to launch the payload, and at no cost to us. This was a precedent for NASA. True, OSCAR's 1, 2, 3 and 4 had been piggybacked on U.S. launches before, but these were military rockets, and we had to convince the decision-makers at NASA that this was a project in the public interest deserving support. Not only did we have to justify the project on the basis of its experimental merits, but we also had to demonstrate that the Australis payload would not jeopardize the safety of the main mission, a Delta-launched weather satellite. We also had to show that adding Australis-OSCAR to the mission would not impact the cost of launch.

The Australis satellite was launched on January 23, 1970 as Australis-OSCAR 5 (AO-5), and the satellite transmitted beacon signals on two and ten meters for 52 days until its batteries expired. We had known from the start that the Australis-OSCAR mission would be a short one since the satellite had no solar panels. But we felt the mission worthwhile nonetheless, because we were able to establish the precedent for piggyback launch by NASA, thermal-vacuum, vibration and other test procedures, methods of integrating the payload with the launch vehicle, telecommand and data collection methods, and the myriad of other details involved with satellite construction, test, integration, launch, licensing and operations.

Later in 1969, we met with Karl Meinzer, DJ4ZC to discuss arranging to fly his two-meter to two-meter inband repeater, but Karl indicated his preference to develop a newer repeater of improved design with an input on 432 MHz and output on 146 MHz. We began to make plans to fly this repeater on one of our future satellites.

Our next satellite, AMSAT-OSCAR 6 (AO-6), launched on October 15, 1972, continued to operate for 4 1/2 years. It contained several important experiments. One was a two-to-ten meter repeater built by Dick Daniels, W4PUJ. Since it was the first of our long-lived transponders, we decided to designate this frequency combination "Mode A". AO-6 also carried an ingenious Morse code telemetry encoder developed by John Goode, W5CAY. Both the two-to-ten meter repeater and Morse code telemetry system were new projects designed to make possible participation by as many hams and students as possible.

AMSAT-OSCAR 6 was followed by AMSAT-OSCAR 7 (AO-7), launched by NASA on November 15, 1974. Like AO-6, AO-7 included a two-to-ten meter Mode A repeater, and it also included the 70 cm-to-two meter repeater built by Karl Meinzer's group in Germany. Being the second frequency combination, it became known as "Mode B". This transponder delivered very strong signals and became very popular. The AO-7 satellite was very successful, and operated for 6 1/2 years.

AMSAT-OSCAR 8 (AO-8) was launched by NASA on March 5, 1978. Although constructed by AMSAT groups, this satellite was sponsored by ARRL to replace the Mode A capability of AO-6, which was no longer in operation. This enabled continuation of educational activities which ARRL had initiated. AO-8 provided service for over 5 years.

The growth of AMSAT and the affiliated family of AMSAT organizations since that time has been simply amazing. A sign of a successful organization is its ability to perpetuate itself and grow. In the United States, AMSAT-NA has had only five presidents over the past 25 years. AMSAT-Deutschland has had but one, Karl Meinzer, DJ4ZC!

But perhaps the most impressive evidence of success of the international AMSAT organization has been the ability to disseminate not only satellite operating information worldwide, but also satellite construction expertise, with satellite contributions from a number of countries. And the list is growing, with the more recent satellite projects in Mexico, Israel and Chile. Who would have dreamed that some day astronauts circling the globe would be communicating using amateur radio, or that small amateur satellites would be computer controlled and be capable of sending pictures back from space.

It is extremely important that all satellite design and construction work be fully documented if it is to be duplicated by others. In the past, the satellite hardware developers have been so busy designing, building and testing their hardware, that often they have not had time to fully document their contributions in such a way that others could build upon their designs. The development and documentation of software has been another serious problem, sometimes delaying the full operating potential of the OSCAR communications hardware in space.

In summary, for many of us, our personal participation in the amateur satellite program has touched our lives and affected us in a very positive way. The excitement of launch of a satellite one has personally helped build is almost beyond description. It can be likened to the birth of a baby, although I am not sure that my wife Suzie would agree. Certainly, some of the world's most worthwhile contributions come from the work of volunteers, motivated only by personal satisfaction. AMSAT is living proof.

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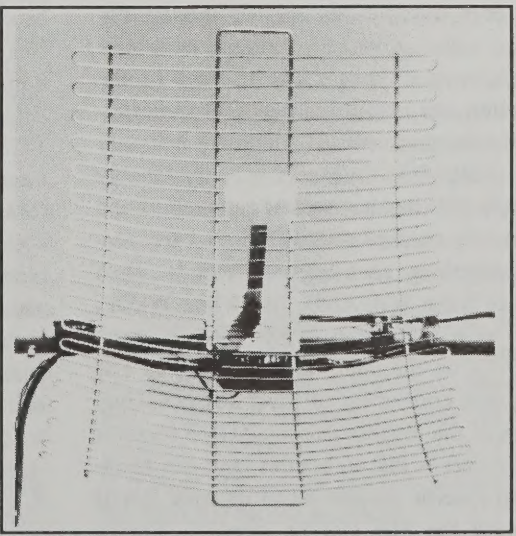

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The New G3RUH 400 Baud PSK Demodulator

by Ed Krome, KA9LNV

Satellite operation is both great fun and can be very instructive. Everybody from the rag chewers to the techno-freaks can find something of interest there. But just operating the birds is missing one of the most fascinating parts of satellite operation. And that is listening to the voices of the satellites themselves.

Telemetry

Since satellites are not simply passive reflectors, they all have an onboard computer (usually called the IHU or Internal Housekeeping Unit) that monitors and maintains the internal requirements of the bird. These requirements include such things as battery charge state and rate, transponder schedules and keeping track of orbital and navigation data. And the birds don't keep these things secret; all convert these vital signs to digital form and transmit them as telemetry. Quick now, (this is a quiz!) what is the most important satellite function monitored by telemetry? How about battery state and charge? Remember, without a properly functioning power source, nothing else matters anyway because nothing else works!

Command Stations

Each satellite has specific ground stations, called command stations, who have volunteered to keep a watchful eye on the satellite and tend to its needs. Some satellites take more tender loving care than others. AO16-PACSAT uses a comparatively simple IHU that has proven quite robust and normally requires relatively little care. Until something goes haywire, that is. Then Bruce Rahn WB9ANQ, Jim White WD0E, and now Russ Platt WJ9F get real busy. AO-13, on the other hand, is complex and requires quite a bit of TLC and tweaking. One of the biggest reasons AO-13 requires more care is that it requires (and can maintain) specific orientation of its solar panels toward the Sun and its antennas toward earth. It is actually "steerable". This steering is, however, a bit different from what one might expect. Instead of some sort of thruster engines, it has on-board "magnetorquers". These devices are basically electromagnets mounted in the satellite's three arms. These electromagnets are cycled at carefully calculated rates and times to produce a magnetic field that acts against the earth's magnetic field and makes it possible to reorient the satellite in space. In this manner, the command stations are able to change the attitude of the satellite to accommodate seasonal changes in Sun angle and eclipses. James Miller G3RUH, Peter Guelzow DB2OS and Graham Ratcliff VK5AGR regularly control the operation of that bird. And do a fine job of it, too. G3RUH presented a fascinating and enlightening paper on controlling AO-13 at the 1993 AMSAT Space Symposium in Arlington Texas (reprinted in a recent issue of The AMSAT Journal) (1). Graham Ratcliff has published two recent articles (2,3) which will whet your appetite by describing some of the interesting things that you can observe from the AO-13 telemetry.

AO-13 Telemetry

Since AO-13 is the most complicated strictly amateur satellite, it provides the most detailed telemetry. AO-13 puts out information in three different forms, CW (at 10 WPM), standard Baudot RTTY and 400 baud BPSK. The General Beacon frequencies are 145.810, 435.656 (no longer functional) and 2400.646 MHz. Sometimes the Engineering Beacon can be heard on 145.983 MHz. The CW and RTTY segments transmit only selected blocks and less information than the 400 baud segment. The 400 baud data is transmitted in 512 byte blocks preceded by a four byte synchronization sequence and followed by a two byte checksum (CRC) and then a 3 second pause consisting of hex 50. A byte consists of 8 bits and is transmitted serially, MSB first.

There are a variety of blocks, each of which has a different letter designation and contents. Some blocks contain plain text and some contain data. Blocks are identified by their first two bytes, which are 1) letter and 2) space. Letters Y,K,L,M,N are text blocks and Q blocks are data. Data blocks alternate with text blocks. The full cycle of all blocks takes 145 seconds. Text blocks (in ASCII) are sometimes messages between the command stations and other times general operations information. New operation schedules and reorientation schedules are published there. And no matter what you read anywhere else about AO-13, the real thing is available right there off the satellite itself. Data blocks contain IHU telemetry in the form of 128 bytes of hexadecimal; the real-time life breath of the satellite with information on power, temperatures, status points and some text material.

A note on obsolescence. This format is so common and well known (it was used on AO-10 also) that it is expected to continue as the standard for future birds, such as Phase 3D. So what you build today will not become obsolete tomorrow.

Receiving 400 baud BPSK

The primary beacon transmits information at 400 baud BPSK, which may seem like a bit of a problem since you probably don't see much of that mode in terrestrial operation. Like none. Receiving the 400 baud BPSK telemetry is easy, but does require a special demodulator. G3RUH has published articles describing two demodulators of his own design. The first, presented to the US audience in Ham Radio Magazine (may it rest in peace) in April 1985, and earlier in Wireless World (4), was the mainstay of the telemetry crowd (and the command stations) for years. James Miller marketed bare circuit boards that were easy to build, required minimal alignment and worked fine. The audio output of a normal SSB satellite receiver was inputted to the demodulator, and the output (usually in the form of serial data) was fed to a computer's serial port and the demodulator took care of all the fancy stuff. Computer programs from AMSAT-Australia and W9FMW were (and are) available to decode the data. The W9FMW program is available through AMSAT. The latest version of the AMSAT-Australia program, called P3C ver 2.4, is available in the USA only from W8GUS. It is also available direct from AMSAT-Australia or from AMSAT-UK. These programs require an IBM type computer.

Over the years, demod users sent their comments back to G3RUH on their experience with the device (5). And, being the first class engineer and designer that he is, James listened and has now produced a much improved demodulator which is the major topic of this article.

Probably the most serious drawback of the first demod design was the requirement for the builder to adjust the frequencies of two phase locked loop circuits. This required a scope and frequency counter and, while it really wasn't very difficult, could be confusing. Also, the unit was published to output parallel data blocks to a computer that was not common on this side of the Pond. It could be easily converted to drive a standard RS-232 serial port.

The NEW Demod!

Now all that is history. G3RUH has completely redesigned the demodulator to produce a better mousetrap. It is, as James describes it, a "load-and-go design. There are absolutely no set-ups, no pots, no tune-ups. If you build the board properly, it will work right-off; audio in, RS-232 out. Sounded fascinating. Since I have some experience with AO-13 telemetry and have this quirk of being an incurable builder, I built one.

You can buy the boards direct from G3RUH in England, either bare board or built up. In the USA, Ron Long W8GUS (Kiron Corporation) carries kits that consist of the board, a complete set of parts and a case which includes plastic laminated overlays for the front and rear panels. Bob Myers W1XT (of R. Myers Communications) sells the completed board, purchased from G3RUH, and a kit consisting of a case and panel mounted parts.

Ron Long supplied us with his complete kit and enclosure. I took it home and was pleasantly surprised to find that the kit not only included the expected parts but also quite detailed construction and usage information. In addition to G3RUH's original manual (20 pages!), a construction sequence, parts list and identification, and board location diagram, all prepared by Steve Todd K2IYQ, are included. Very helpful. And Ron's kit had the right quantities of the right parts, always a good sign. Figures 1 and 2 show the final result.

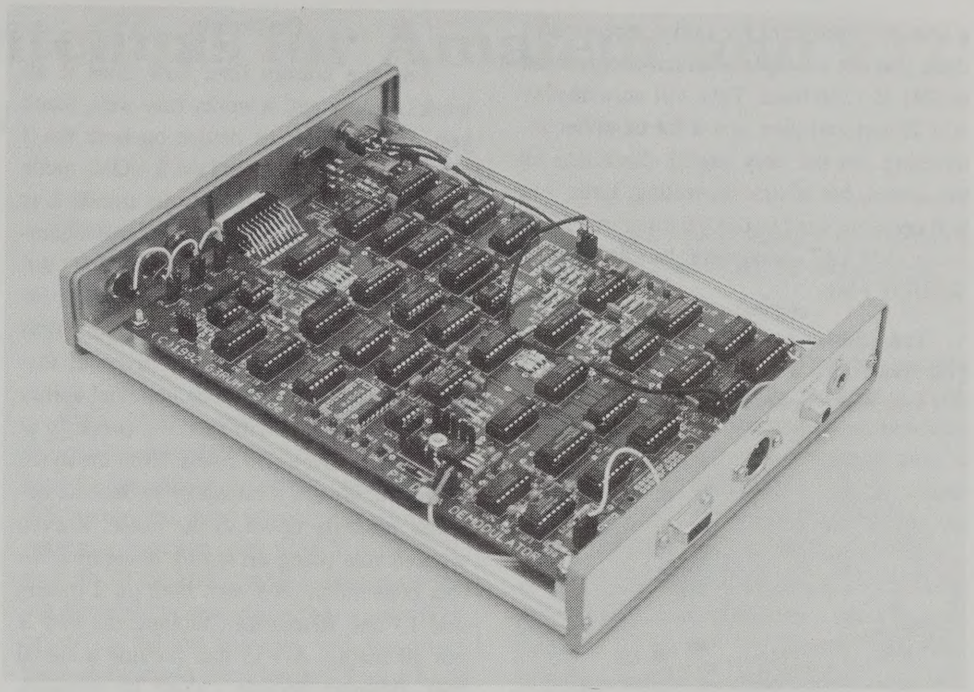


Figure 1: Inside view of 400 Baud PSK Demodulator

One advantage of buying a kit rather than searching out the parts on your own is that a few of the parts are not easy to locate. An example is that the board includes a bar-type LED assembly that should be mounted on the front panel of the completed unit. In the beginning W8GUS tried various approaches including 20 individual wires from the horizontally-mounted pcb to the panel-mounted LED, to homebrewing a right angle socket from a wire-wrap socket. These approaches had their problems. For example with the wire-wrap idea, not only was it difficult to bend the pins appropriately but you had to file the 20 square pins to make them fit the size holes in the pcb. After a lengthy search W8GUS located a commercial right angle socket which solves the problem very nicely, see Figure 3.

Now a minor warning.... This is a 6" x 8" board stuffed with 40 IC's and a handful of discrete components. There are altogether, including resistors, sockets, etc., 180 parts of 67 different types. It is not difficult to build, but you must pay attention. And be VERY careful with the soldering iron. Remember, it takes about 20 dB more time to find a construction fault or solder bridge than it does to create one! I personally do all my DIP soldering with the aid of a Sears headband binocular magnifier. Why? Because I'm over 40 and can't see the little buggers!

Before you start construction, do the following: Read everything over. Then read it all again. You need to think about things like what kind of box to put it in (Long's box made a nice looking package) and what kind of interfacing you want to connect to your receiver. Then build.

Steve Todd's construction checklist works fine. I followed it to the letter and the board went together with no problems. As recommended, I did voltage checks on the completed board (see section 6 of G3RUH's manual) before I installed any IC's (sockets were used). Incidentally, although it proved not to be necessary, I have a habit of measuring the actual value of resistors before I stick them in a board. That guards against both defective components (rare) and "pilot error" (common). Watch orientation of diodes and resistor packs. Finally, really study the completed board carefully. It is amazing how easy it is to miss some of the several hundred solder joints.

W8GUS supplies front and rear panel plastic-laminated templates that you simply attach to the panels using spray adhesive and then cut out marked areas for the switches, connectors and indicators. There is a clear area which forms a window for the bar-LED tuning indicator.

Operation

What, no alignment? How could that be? But truly, no alignment is required. Connect audio in (USB), computer RS-232 out and power and find AO-13. You don't need a telemetry program for initial reception of data; just use a simple terminal program set to 8N1 at 1200 baud. This will only display ASCII text and give you a lot of rather interesting but not very useful characters on the screen, but is fine for testing. Later you will certainly want to use the program "P3C" from AMSAT-Australia bundled with W8GUS's kit.

Tune slowly across AO-13's beacon and you should see a variety of LED's light to tell you that the board is hearing the bird.

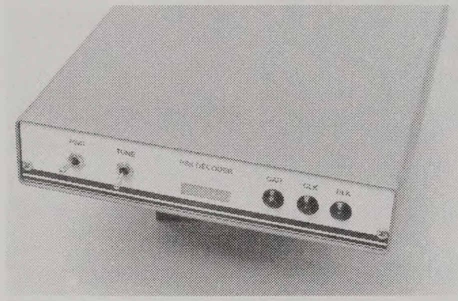


Figure 2: The Completed Kit

Section 1.3 of the manual details what you should see, but in a nutshell, the CAR and CLK indicators should glow when the tuning bargraph indicator is near the center of its range. When the start of a block is detected (13 second intervals), the BLK indicator will light and stay on for the duration of the block. You should see data on the computer. With P3C you will also note the byte count going up during the 13 second collection interval. Neat stuff.

Options

The new design incorporates several options, including auto tuning, the ability to change demodulator center frequencies and two optional output types. Eight bit parallel plus strobe (TTL) and regenerated T(+)CLK outputs are available, though most users will only use the RS-232 serial output.

Completely new to this demodulator is an opto-isolated automatic receiver tuning function using the mic click tuning available on most 2 meter SSB radios. The original demodulator required manual retuning for Doppler shift; now the board will do it for you. The board is set up so that appropriately placed jumpers will customize the up/down tuning pulses to drive all common digitally tuned transceivers and receivers. This is a neat feature. If desired, you can still tune the receiver manually.

On the air

And the bottom line: how does it all work? Simply put, it works very well, thank you. I have used the device on both the 2 meter mode B beacon and the 2.4 GHz mode S beacon with excellent results (mode L is no longer operational). The biggest operational difference between the new demodulator and the original is the tremendous increase in sensitivity. G3RUH claims it is only 2-3 dB better than the original; that sure makes a big difference in actual ability to decode! And it will function properly at surprisingly low audio levels. Even the mode S beacon, always a bit sticky to decode, decodes properly down to the noise. It even worked fine being driven by homebrew direct conversion receivers, both on 2 meters and 13 cm. Remember, though, the box is not all magic. AO-13 can provide a signal that, although audible, cannot be decoded. This is due to spin modulation induced fades, which simply drop off to nothing. No signal in means no data out. Try again later.

Finally...

Don't miss half the fun! Buy or build a telemetry demodulator and monitor AO-13 regularly. Read the text blocks for operational and schedule information. The most accurate information is always on the satellite itself. Pay attention to specific parameters and watch them change. For a new user, it is especially interesting to watch the solar panel currents which change as the satellite rotates, and the transponder AGC and current parameters and how they change with loading. In a short time, they will become like old friends. There for you to enjoy.

The newest 2.4 version of P3C includes three improvements over earlier versions. First it supports COM3 and COM4 as well as COM1 and COM2. Second it is interrupt driven which means you can run a TSR program such as the one frequently used in conjunction with the Kansas City Tracker in the background while also running P3C without losing any incoming telemetry characters. Third, the program can now display the Event blocks which are embedded in each Q block. An Event is an out of the ordinary occurrence such as a memory error due to radiation flipping a bit in memory or abnormally low or high temperatures etc.

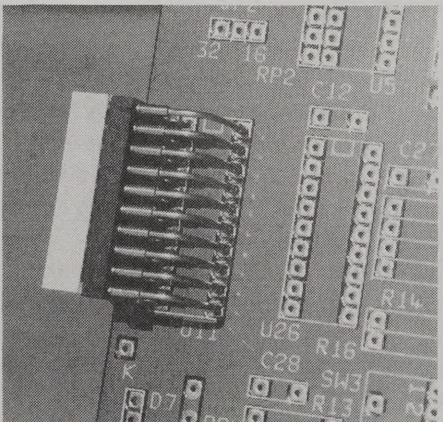


Figure 3: Right Angle Socket for the Tuning LED

I also recommend that you obtain a copy of Gould Smith's book on telemetry (6) which is available from AMSAT-NA. The chapter on AO-13 will help you as you delve more deeply into the subject of AO-13 telemetry. For example one subject not discussed previously in this article is the Whole Orbit Data (WOD) which is contained in the K blocks transmitted by AO-13. The P3C program will receive the K blocks but you need additional software to fully decode and plot the WOD. But that is the subject of another article!

Support of P3D

James donates half the profit from sales of his demodulator printed circuit boards to the P3D construction fund. In addition W8GUS sends $20 from each sale of P3C to the P3D Fund in the name of AMSAT-Australia.

Complete kit and case available from:

Dr. Ron Long W8GUS Kiron Corporation 1516 Essex Rd. Columbus Ohio 43221 (614) 481-0542 Modem kit and enclosure $158 + $5 S&H. P3C.EXE ver 2.4 $25 (with kit), $30 alone + $3 S&H.

Populated board and kit available from:

Bob Myers W1XT R. Myers Communications PO Box 17108M Fountain Hills, AZ 85269-7108 $298 plus shipping. Includes the 2.0 version of P3C.EXE.

References:

1. J. Miller G3RUH, "Managing OSCAR-13",The AMSAT Journal, Vol 17, No. 1, Jan/Feb 1994, pp 4-13.
2. G. Ratcliff VK5AGR, "Monitoring AO-13 Battery Voltage", The AMSAT Journal, Vol 16, No. 4, Jul/Aug 1993, pp 28-29.

Continued on Page 17

Quadrifilar Antennas for Amateur and 137 MHz Satellites

by Dave Guimont, WB6LLO

INTRODUCTION

Most satellite operations today require antennas with considerable gain for both the up and down links. The high gain arrays are unwieldy; they require a fairly substantial rotator system, and they are certainly difficult if not impossible to use in most mobile or portable applications. This situation is changing rapidly. The latest microsats require much less gain for both up and down links. Phase 3D's proposed antenna systems with increased EIRP will certainly reduce the need for as much antenna on the ground.

The antenna described here is an attempt to make progress in that direction. It will greatly reduce and may eliminate the need for a rotator system for some operations. Your input is greatly needed to assess its potential.

First, thanks are in order for Jack W3TMZ, Red KD7BC and Phil KK6NS. They assisted with the bibliography on a surprisingly widely documented subject. The project started in earnest after reading the subject matter in The Satellite Experimenter's Handbook, 2nd edition. Use it and the information here, and you will have no trouble constructing the antenna. It is reproducible. Four have been built for 70 cm and four for 2 meters, and the performance is identical. A friend living on a sailboat says the 137 MHz version outperforms any other antenna at the marina.

It is inexpensive. If you buy everything new the cost will be less than ten US dollars for the 70 cm version. The cost of the 137 MHz or 145 MHz version is less than twenty dollars. Build your next antenna, and send the money you save to help construct Phase 3D! With the additional gain provided by Phase 3D this antenna (or one very similar) is a stepping stone for excellent communications. The quadrifilar has been used (in combination with KLM's for the other half of the link) for contacts on both mode B and J on Oscar 13. All testing and evaluation has been done empirically for want of sophisticated equipment. And that is the way the antenna was constructed.

Please BE AWARE that the following discussion is based on using a Bird wattmeter and a homebrew field strength meter along with on-the-air comparisons.

RESULTS

First, polarity. Nothing in the available references describes circularity with reference to the physical "screw construction". All testing has been accomplished on permanently installed pairs (RHCP and LHCP) on both 70 cm and 2 meters. Instant switching allowed comparison between signals received on the test antennas with the downlinks as received from Oscar 13 on a KLM 40-CX and a 22-C. A dual polarity 70 cm Lindenblad was constructed some time ago. A pull on a nylon line in the shack rotates the position of the Lindenblad elements enabling instant polarity comparisons. The Lindenblad shows marked polarity reversals. For 2 meter testing some comparisons were made with the Bicycle Wheel Quad described in the ARRL Antenna Compendium, Volume 1, q.v.

Suffice to say that a "physical left hand screw construction" yields RHCP and vice versa as indicated by the comparison testing to date. I would really appreciate any information readers have or subsequently discover through testing. Though the Lindenblad exhibits a pronounced polarity change in contrast to the lesser change of the quadrifilar, the gain of the quadrifilar is definitely higher in all quadrants.

GAIN

Equipment is not available to determine gain accurately. Comparisons with a crude attenuator indicate 4 to 5 dBic. Rotating the 70 cm antenna in azimuth with a U-100 rotator and a fixed elevation of 45 degrees it copies most everything above 20 degrees elevation on both AO-22 and Kitsat. This while using a fixed vertically oriented quadrifilar on the 2 meter uplink with 60 watts up the pipe. The feedline and connectors have been optimized and hardline is used on both links. The runs are short and the rooftop at my QTH "looks" at everything above 10 degrees elevation on all headings. An optimized station should be able to "save" their rotators for operation on Oscar 13 until Phase 3D comes along.

PATTERN

"Swinging" a hand held version pointed at known RF sources indicates a beam width of 140 degrees. On the air testing indicates some scalloping, but not enough data is available to really make that determination. Deep fades are also experienced using the "instant polarity change" Lindenblad, and they do not seem to be caused by polarity reversal. The construction described here rotates the loop a half turn. Various other degrees of rotation yield pattern changes and experiments with those rotations are continuing. Results of experimenting in that direction would certainly be appreciated.

VSWR

The antennas are all less than 1.2 to 1 using the measurements and the materials described. The RHCP 70 cm antenna being used now shows less than 1/2 watt reflected using 100 watts output and a 10 watt slug in the Bird on reflected power. That of course is no indication of antenna efficiency, but it's a good place to start.

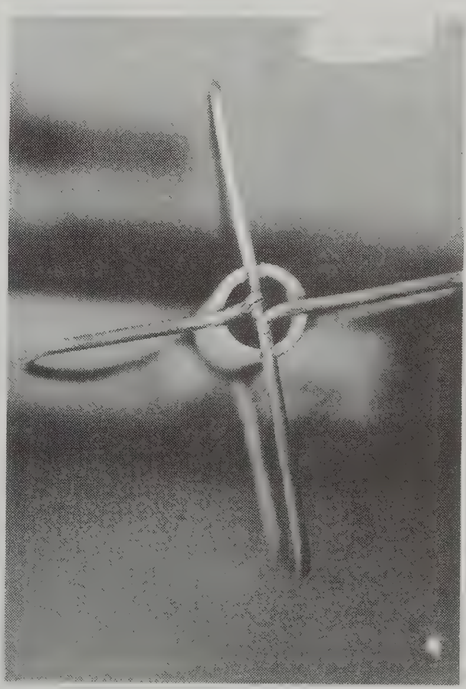


Figure 1: Top end view of 70cm Quadrifilar Helix

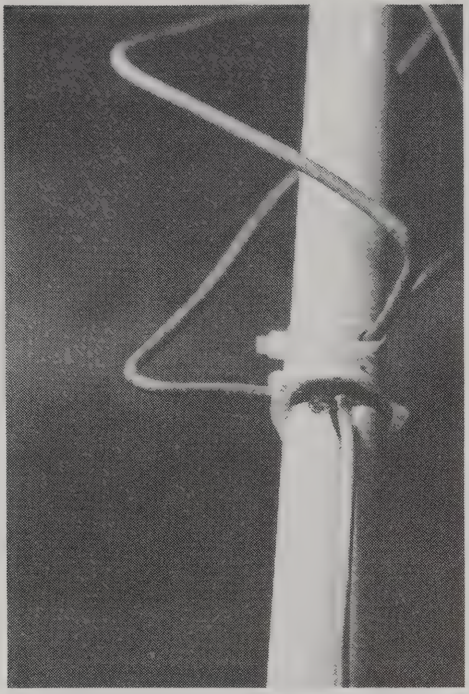


Figure 2: Bottom portion of 70cm Quadrifilar Helix

Three views of the antenna have been uploaded to UO-22 and KO-23. They show the feed point, feedline termination and a view of the complete antenna. Basically the same information is shown in the photos which accompany this article. Two meter experiments are continuing and that information should be available soon.

PERFORMANCE

Short term testing of any antenna system provides only a glimpse of its eventual performance. Initial results with the 70 cm quadrifilar in a fixed vertical orientation on receive on the microsats indicates superior performance as compared with the Lindenblad, j-pole and crossed dipoles. In a fixed vertical position the average download at 9600 baud averages 150K on passes above 20 degrees elevation. Using a fixed antenna elevation of 45 degrees and presetting the azimuth at the center of the range for that pass yields 200K. A pair of antennas with a fixed elevation of 45 degrees fixed on north/south reciprocal headings yields 250K. The pair is coupled with an inexpensive homebrew splitter fashioned from two type N connectors and some copper tubing. (to be described in a subsequent article)

If you fix one antenna at 45 degrees elevation, and rotate it in azimuth only, 300K is possible on a pass with reasonable elevation. This method belies the goal of a rotatorless system, but it does give an indication of antenna efficiency.

CONSTRUCTION

Materials list for the 70 cm quadrifilar antenna:

3/4" schedule 40 PVC pipe ~ 30".

50 ohm solid-copper-jacket Teflon hardline .141" OD ~ 19"

(I got mine at a swap meet and do not know the product number. It compares to Belden 50 ohm conformable coax #1168A, and that should work just as well.)

#6 solid copper wire .161" diameter EXACTLY 44 3/4" in length.

A suitable type N connector.

Materials list for the 145 MHz quadrifilar antenna:

3/4" schedule 40 PVC pipe ~ 48"

1/4" Heliax FSJ1-50 ~ 50"

(This product has a foam dielectric, but if a large soldering iron is used at the connections there is absolutely no deterioration of the foam. Any 1/4" Teflon hardline will work just as well.)

1/4" OD soft copper tubing. EXACTLY 130 1/8"

Suitable type N connector. The connector for Heliax is very expensive, but an N connector can be adapted very easily with suitable bushings.

Materials list for the 137 MHz quadrifilar antenna:

3/4" schedule 40 PVC pipe ~ 48"

1/4" Heliax FSJ1-50 ~ 52"

1/4" OD soft copper tubing. EXACTLY 137 1/4"

Suitable type N connector

Using the instructions given below it is imperative that you have access to the Satellite Experimenter's Handboook, 2nd Edition or a similar depiction of the antenna. The one depicted is a physical LH-screw thread, and it exhibits RHCP.

Cut a cross in the end of the PVC pipe that is 3/16" wide by 3/8" deep. For 145 and 137 MHz the cut is 1/4" wide by 3/8" deep, see Fig. 1. (Figure 1 is a mock-up made for photography only. The 3/4" cap on the top end of the completed antenna is for a planned 2 meter combination experiment, and it makes it difficult to photograph the feed point.)

Make a mark on the pipe at 7" and 7 1/2" to line up with each pair of the cuts you just made. Cut a slot at these marks 3/16" wide to 1/2 the width of the pipe. These slots hold the bottom ends of the two loops. Cut a "V" notch in the bottom of the lower slot. The hardline will exit through this slot. The marks are 19 1/4" and 21" for 145 MHz; 20 3/8" and 22 1/4" for 137 MHz. The width of the cut is 1/4" for these two frequencies, see Fig. 2.

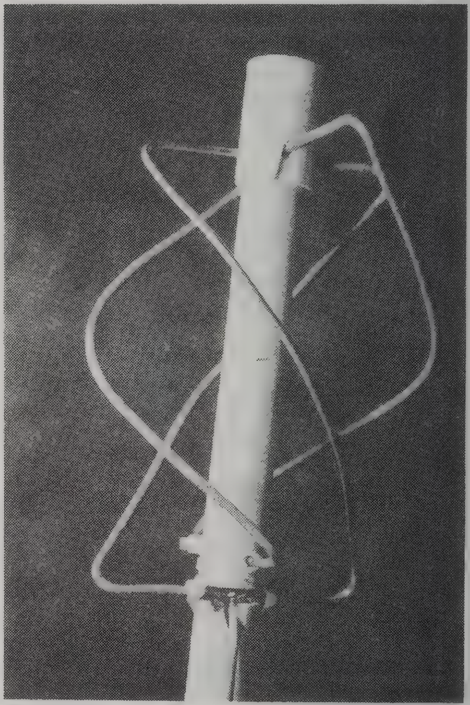


Figure 3: The finished product for 70cm

Solder the connector to the copper hardline. Mark the hardline from the opposite end as follows: 1/4", 2 3/8", 11 7/8", 14". Remove the copper outer shell at the 1/4" mark, and 1/8" of the Teflon from that end. Bend the hardline to form approximately 70 degree angles as depicted in the photos. Do not be concerned about the shaping of the center section, that will be done when you mount it on the PVC pipe.

For 145 MHz mark the Heliax: 1/4", 6 3/8", 34 3/4", 40 7/8", 50". For 137 MHz mark the Heliax: 1/4", 7", 37", 43 3/4", 52".

Anneal the copper wire. The fireplace works just fine. It work-hardens rapidly, so bend gently to straighten after annealing. Mark the copper wire as follows: 1/4", 2 3/8", 11 7/8", 14", 16 3/8", 26 7/8", 31 5/8", 42 1/8", 44 1/2", 44 3/4". Hacksaw a slot on both ends to the 1/4" mark. Form that slot around a suitable mandrel to accommodate the coaxial cable. Form the copper as shown in the drawing starting with the first bend at 2 3/8". The copper wire to the 90 degree bend forms the other half of the outer (smaller bifilar). The rest of the wire forms the inner (larger bifilar).

For 145 MHz mark the tubing: 1/4", 6 3/8", 34 3/4", 40 7/8", 47 7/8", 78 3/8" 92 3/8", 122 7/8", 129 7/8", 130 1/8".

For 137 MHz mark the tubing: 6 3/4", 36 3/4", 43 1/2", 50 7/8", 83", 97 3/4", 129 7/8", 137 1/4".

If the tubing is used be certain to anneal it prior to shaping. It may be helpful to make some filars from scrap, easily formed wire. The dimensions can be approximate, and you will have a rough model to aid in bending the final product. A different color for the coax portion of the model will also help. That is the procedure I used to make the prototype from the Handbook article.

Center the bottom of the inner loop in the slot closest to the cross-cut end. Secure it with a nylon ty-wrap or some other non-conducting material. Solder the prepared end of the solid-copper wire to the lower right angle bend of the copper hardline. Gently bend it to exit at the "V" as shown in Fig. 2.

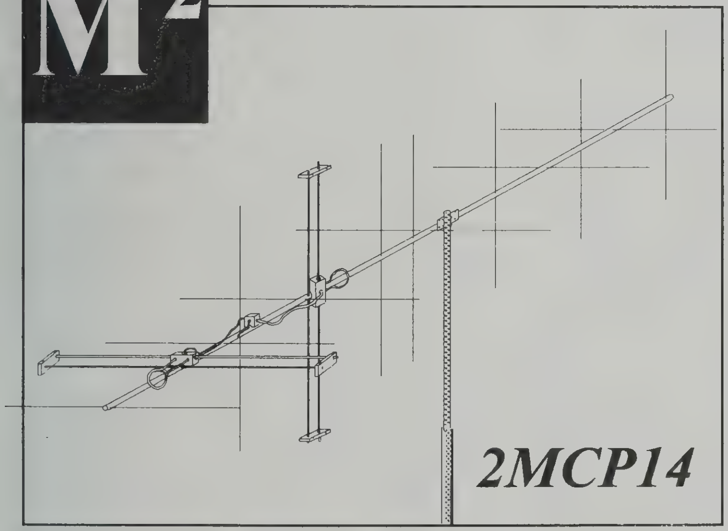
Insert the 90 degree bend in the wire in the cross slot. At this point carefully form the wire and the hardline to gently arcing bends similar to the depiction in the Handbook and Fig. 3. Solder the top end of the slotted copper wire to the bitter end of the copper jacket. Solder the center conductor of the hardline to the center of the 90 degree bend as shown in Fig. 1.

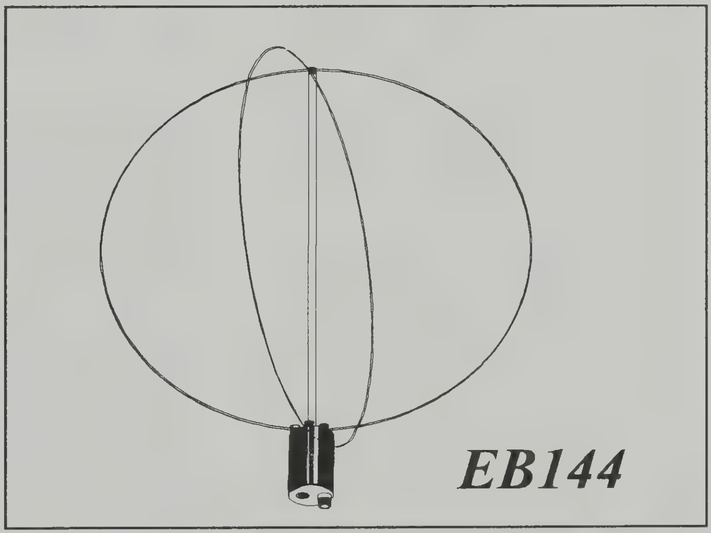
Construct a spacer of any suitable insulating material to stand off the hardline to permit coaxial cable attachment, and secure it with insulated tape. Some reshaping of the four antenna sections may be necessary to provide uniform separation.

You may disseminate the information in this article as you see fit but if you add notes, and you probably will, please keep the original document intact. Questions down the line are extremely difficult for me to answer if we aren't playing from the same sheet of music. I'll be very happy to display any views one may wish on SSTV on AO-13.

I'm available on LUSAT, PACSAT, FO-20, UO-22 and most of the AMSAT OPSNETS. I'm also good in the Callbook and the phone book. Specific information you can give me regarding pattern and measured gain of any quadrifilar antennas you construct would be most helpful. Particularly let me know of negative results concerning any testing you may perform.

M^2 Enjoy consistent, reliable satellite communications!





The 2M-CP14 is a circular polarized antenna with match and gain optimized between 144 and 147 MHz for the serious OSCAR user. Computer design keeps spurious side lobes small for optimum S/N ratios and forward power. Sealed, weather-tight driven elements give years of trouble-free performance - a perfect partner to the M^2 circular polarized 436CP30.

See the Sept. QST review and find out just how well this versatile omnidirectional performer accesses high and low orbit satellites (inc.137 MHz weather). The compact EB144 is also surprisingly effective for mobile, nets, contests, and field day operations. Polarity is horizontal at the horizon, RHC overhead. For UHF, there's the companion EB432.

WATCH FOR OUR NEW S BAND ANTENNA SYSTEMS...COMING SOON!

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P3D Progress Report

Marburg Meeting, February 1994

by Peter Guelzow, DB2OS

(translated by Don Moe DJ0HC/KE6MN)

During the week of February 10-16, 1994, a further project meeting was held in Marburg to discuss the international P3D satellite project. Attention centered primarily around the receiver front-ends, the onboard computer (IHU) and RUDAK, as well as several transmitter final amplifier stages. The participants were invited to attend by Dr. Karl Meinzer, DJ4ZC, AMSAT-DL President and Project Leader of P3D, and by Werner Haas, DJ5KQ, Vice-President of AMSAT-DL.

Fuel Tanks Arrived

Dick Jansson, WD4FAB, AMSAT-NA Vice-President of Mechanical Engineering, attended mainly in order to discuss various aspects and details of the satellite structure with Dr. Karl Meinzer, DJ4ZC, and Konrad Mueller, DG7FDQ. Dick Jansson also reported on the progress of the construction of the flight version of P3D, currently underway at the Weber State University in Utah. In the meanwhile, Konrad Mueller has continued work on a flight-ready engineering satellite structure.

A particular highlight of the meeting was the arrival of the P3D propellant tanks from Russia. Seven tanks were delivered, although one tank had been subjected by the manufacturer in Russia to a destructive pressure test. At a bursting pressure of 63 bar (kg/cm^2) the required technical specifications have not only been fully achieved, but actually significantly surpassed. Each tank can accommodate 50 liters of propellant. The tanks were manufactured in Russia under contract from AMSAT-DL according to AMSAT specifications. Favorable conditions for purchase and delivery could be arranged thanks to the efforts of AMSAT-UA (Russia). Following a brief inspection the tanks were forwarded a few days later by air freight to Orlando, Florida, where the integration into the satellite and the mounting of fitting, valves and pipes will be performed under the direction of Dick Daniels, W4PUJ.

IHU-LAN

Lyle Johnson, WA7GXD, arrived at the meeting together with Dick Jansson and was warmly welcomed by all participants as a new member of the P3D team. Lyle Johnson is certainly known through TAPR which he co-founded and which has provided decisive impetus to the further development of packet radio. Among other things, Lyle co-developed the first TNC-1. He is also a member of the GPS project for P3D. In lengthy conversations with Karl Meinzer, Peter Guelzow (DB2OS), and Gerhard Metz (DG2CV), Lyle Johnson expounded on the recommendation by AMSAT-NA to use the AART chip from Motorola in the LAN. Although the IHU-LAN had already been declared dead at the previous international P3D meeting in Munich, this new thrust was favorably, but conclusively evaluated and factually discussed. The AART-LAN had been previously discussed in the LAN group, but it did not fulfill the requirements for data security or speed.

According to Lyle Johnson, the original AART design, which had been promoted by Tom Clark (W3IWI), has since undergone a series of improvements. In particular the asynchronous serial bus interface was reconfigured for differential bus drivers in order to significantly reduce both the sensitivity to interference and the generation of interference in the satellite. Further improvements affected the circuit design and the expansion of the I/O capabilities. In fact the AART design presented is certainly an interesting alternative for a LAN system aboard the satellite. In contrast to the Microsats (AO-16, DO-17, WO-18, LO-19, IO-26 and AO-27), the requirements of the P3D satellite are fundamentally different and also significantly higher. The critique centered mainly on the fact that the AART bus only offers conditional transmission security since other than a single parity bit no other data checking is provided, such as CRC. An external hardware solution could be realized, but increases the complexity. Furthermore the transmission speed of 9600 Bit/s in the AART-LAN is too slow for P3D.

To acquire navigational and attitude control information, the onboard computer (IHU) must be able to read the digital inputs and outputs within a 20ms time slot. The AART does not fulfill this requirement in contrast to the previous cable harness or the LAN configuration recommended by Guelzow and Metz. A further disadvantage to the AART is that it can transmit only a 7 bit byte at a time. Various functions in the satellite, such as the sensors and control of the gyroscopic wheels, require at least 8 bits per data byte. The additional effort to overcome this difficulty seemed excessively complicated to the participants.

The group came to the unanimous conclusion that the LAN concept based on the AART is unfortunately infeasible. Peter Guelzow explained for Lyle Johnson's benefit the status of progress on a LAN implemented with the CAN bus. A corresponding controller had been presented at the previous meeting in Munich and two additional limited versions have been developed by Peter using different CAN chips from NEC and Philips. The CAN bus LAN cannot be implemented for the IHU LAN due to the current uncertainty about the radiation hardness of this technology. For reasons of redundancy, a supplemental controller built from discrete CMOS IC's could be integrated into the LAN controller. Gerhard Metz had already accepted this assignment. However, he unfortunately could not realize this design for a variety of reasons; primarily, the immense number of discrete IC's is unreasonable. It thus became clear that the CAN bus cannot fly as IHU LAN since the risk would be excessive without redundancy.

The CAN bus and Peter's LAN controller will fly with P3D nonetheless as an experimental LAN as part of the RUDAK LAN. This LAN could provide additional telemetry and telecommand functionality. Lyle Johnson extended the offer to arrange for radiation testing. Peter and Lyle agreed to cooperate regarding the construction of circuit boards and modules for the CAN bus LAN controller as well as the CAN bus interface developed by Peter for the printer

AMSAT-DL President and Phase 3-D Team Leader Dr. Karl Meinzer, DJ4ZC, (Left) along with Konrad Mueller, DG7FDQ, (Right) inspect one of the satellite's propellant tanks recently delivered to AMSAT-DL's Marburg Headquarters. Favorable conditions for the purchase and delivery of the tanks were arranged through the efforts of AMSAT-UA (Russia). *(AMSAT-DL Photo)*

port of a PC or notebook computer. A complete set of documentation and specifications for the CAN bus and the LAN controller has already been exchanged. Lyle also received from Peter two fPD72005 CAN bus chips from NEC and two CAN bus driver IC's for various experiments and radiation testing since such components are still rather difficult to obtain in the USA.

As a consequence, the decision stands that had already been made in Munich to stay with a cable harness similar to what had been implemented in OSCAR-10 and OSCAR-13. At this time there is unfortunately no reliable alternative that could be realized within the time remaining.

New Old IHU

The ensuing discussion centered around the consequences to the IHU from dropping the LAN. Karl Meinzer explained the software aspects and how the old IHU could fully satisfy the requirements of P3D. Although it would of course be "better" to implement a more modern CPU, there is really no reason to do so. The Sandia 1802 CPU is adequately radiation resistant and has been successfully flown aboard AO-10 and AO-13. The old IHU can therefore be used for P3D without major modifications, although additional I/O functions will be needed for the attitude control system and other experiments.

Thankfully Lyle Johnson announced his willingness to take on the redesign of the IHU and the construction of flight unit. This is very welcome additional support for the P3D project since the available manpower is severely limited in this very critical area. Lyle Johnson will initially evaluate which changes need or would be advisable to be performed on the current circuitry. He will then submit his recommendations to Karl Meinzer. As soon as the details have been clarified, Lyle along with Chuck Green and the local AMSAT group will construct the prototypes and the flight version. A cooperative effort was agreed to, in which an early prototype will be delivered to Peter Guelzow for final hardware and software tests. Assuming all goes according to plan, this should occur in late May.

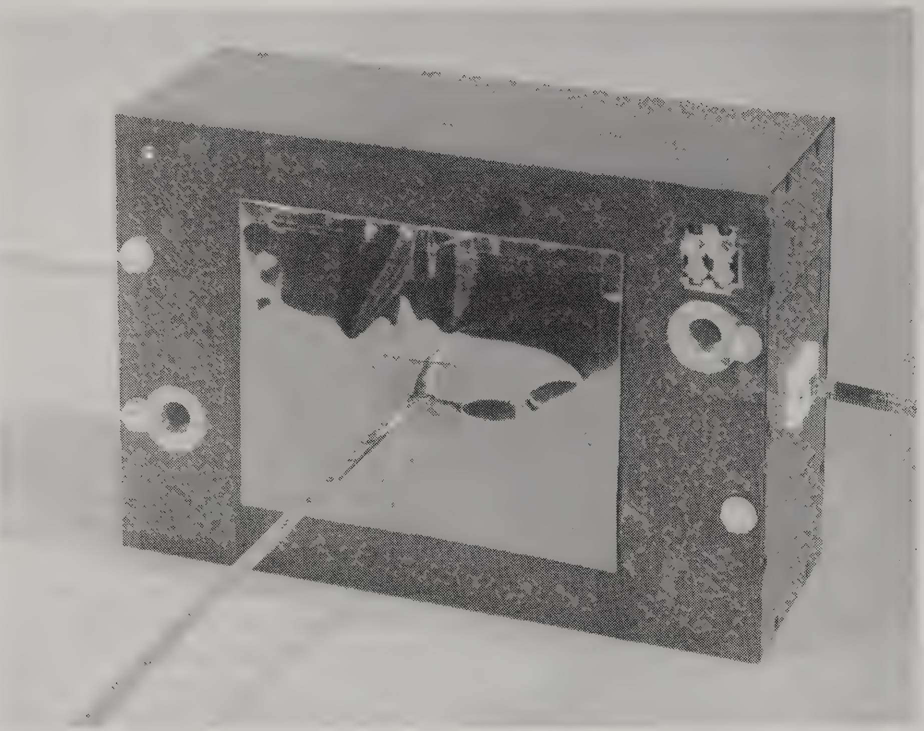
Karl Meinzer further agreed that the IHU must somehow communicate with the GPS experiment. This could take place either directly, via an interface to RUDAK or over the RUDAK LAN. To this aim, the IHU could be connected either to RUDAK directly via a parallel interface, such as dual-port RAM with handshaking, or through a CAN bus controller to the RUDAK LAN. In order to keep the line lengths of the parallel interface short, the RUDAK modules have been relocated to close proximity to the IHU.

RUDAK-U & RUDAK-E = RUDAK-UE

As a result of a suggestion by Peter Guelzow, a new arrangement for RUDAK results in RUDAK being split into a user section, preliminarily designated RUDAK-U, and an experimental section, RUDAK-E. This decision had been preceded by extensive conversations with Lyle Johnson in which he explained the hardware of AO-27 (Eyesat/AMRAD OSCAR-27) with the help of flight-level multilayer printed circuit boards. This hardware would allow six uplink channels and at least 16 Megabyte of RAM disk. Without question, Lyle has had very extensive experience in designing onboard computers and was able to present the possibilities very convincingly. Within two months he and his team had accomplished a complete re-design of the Microsat hardware for AO-27. He was also closely involved with the hardware of the other Microsats and Pacsats. Lyle, Peter, Gerhard, Stefan and Karl extensively discussed the other possibilities and interfaces between RUDAK-U and RUDAK-E and were in full agreement with the advantages of the cooperative effort. In close cooperation with Peter Guelzow, Lyle Johnson will take over the development, coordination and construction of RUDAK-U. Lyle will clarify with his colleagues the degree that the AO-27 design could be adapted for P3D and how to proceed henceforth.

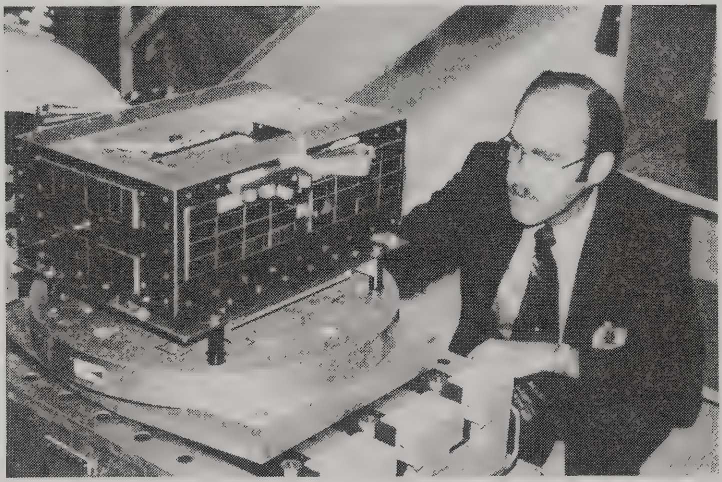
Werner Haas presented Lyle Johnson with the "red" RUDAK book for AMSAT OSCAR-21. This book contains all documents, circuit diagrams and other details relating to the construction of RUDAK-II. The RUDAK group in Munich will concentrate its efforts mainly on the experimentally oriented RUDAK-E, whereas RUDAK-U is essentially a continuation of the hardware and software already successfully implemented aboard the LEO PACSAT. Thus RUDAK-E will promote advanced experiments such as highspeed modems, DSP and new protocols. Further technical details of RUDAK-U and RUDAK-E will be reported by the project groups as appropriate.

Continued on Page 18

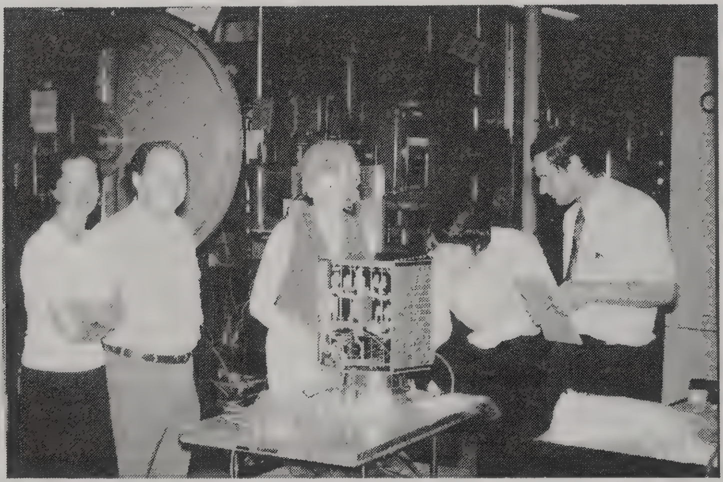


NATIONAL AERONAUTICS AND SPACE ADMINISTRATION WASHINGTON, D.C. 20546 FOR RELEASE: January 23, 1970 PHOTO NO. 70-H-2 LOMPOC, CALIF. — TIROS-M LAUCHED —Two satellites — ITOS-1 and OSCAR-5 — were successfully orbited this morning in the launch of Delta 76 from the Western Test Range. Liftoff time was as scheduled — 6:34 a.m. EST, January 23, 1970. ... This photo shows the secondary payload, Australis-Oscar 5, a piggyback satellite that was built by a group of amateur radio operators at Melbourne University in Australia, giving rise to the "Australius" portion of its name. The Radio Amateur Satellite Corp., (AMSAT) a group of United States amateurs, prepared the satellite for launch, testing and qualifying it to comply with NASA requirements. OSCAR is an acronym for Orbiting Satellite Carrying Amateur Radio.

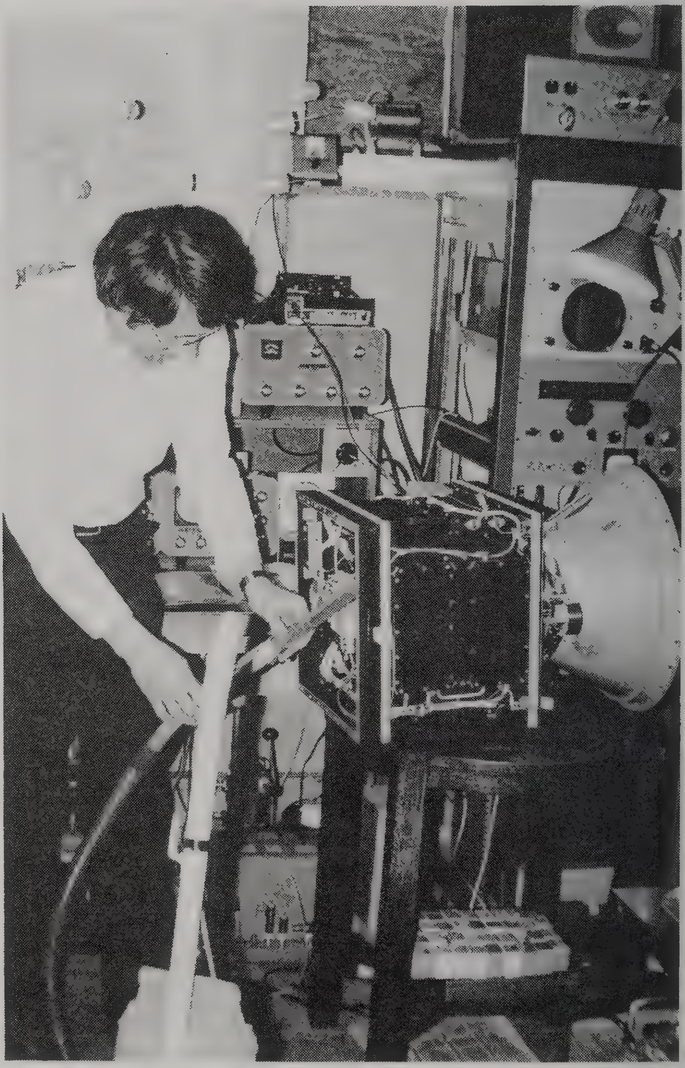
Australius OSCAR 5.



Dick Daniels with OSCAR-6 during vibration testing, 1972.

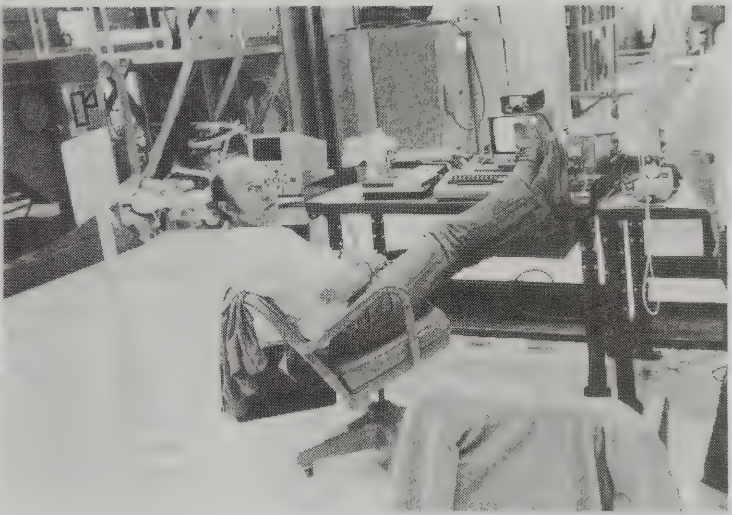


OSCAR 7 is readied for thermal vacuum testing, 1974.



Jan King doing the final cleaning of OSCAR 8, 1978

Marie Marr mounts a wiring harness in the ill-fated Phase 3A spacecraft, 1979.



Karl Meinzer awaits the results of the thremal vacuum tests on Phase 3A, 1979.

Tom Clark and Harry Yoneda at the AMSAT lab in the early 80s.

The OSCAR 10 (Phase 3B) project team.

New 400 Baud PSK Demodulator . . . Continued from page 10

3. G. Ratcliff VK5AGR, "AMSAT-OSCAR-13 Eclipses from 05Apr89 to 27Apr89", The AMSAT Journal, Vol 16, No. 6, Nov/Dec 1993, pp 30-31.
4. J. Miller G3RUH, "A PSK Telemetry Demodulator for OSCAR 10", Ham Radio Magazine, April 1985, pp. 50-62; also "Telemetry Decoder for OSCAR-10", Electronics & Wireless World, October 1984, pp 12-21.
5. E. Krome KA9LNV, "Modifications to the G3RUH 400 baud Telemetry Demodulator", AMSAT Journal, July 1990, pp.19-20
6. G. Gould Smith WA4SXM, "Decoding Telemetry from the Amateur Satellites", AMSAT-NA, Box 27, Washington, DC 20044.

Board of Directors Nominations

The time has again come to submit nominations for the AMSAT Board of Directors. AMSAT Member Societies, or five individual members, may make nominations of fellow AMSAT members to serve two year terms. Three seats on the seven member Board must be filled this year. The three current Board members whose terms are expiring are: Tom Clark W3IWI, Andy Mac Allister WA5ZIB and Joe Kasser G3ZCZ/W3 . Be sure that anyone you nominate agrees to serve and understands that meeting attendance is necessary, if the organization's business is to be conducted. There are generally two Board meetings per year - spring and fall. They are almost always held over weekends. Nominations should be marked "BoD Nomination" and sent to: AMSAT 850 Sligo Ave. Suite 600 Silver Spring, MD 20910, and must arrive by June 15, 1994.

P3D Progress

Continued from Page 15

P3D Navigation

During several hours of conversation, Dr. Karl Meinzer and Dr. Stefan Eckart (DL2MDL) analyzed the difficulties of attitude control, various algorithms and available sensor technology. From their new findings, CCD cameras currently appear questionable as star sensors since radiation damage to the CCD elements is expected to shorten their useful life. Alternative and additional solutions based on Earth and Sun sensors are currently under investigation.

Transmitters

On Sunday, February 13, 1994, Daniel Orban (ON4AOD), and a colleague visited Marburg briefly in order to clarify with Dick Jansson certain questions about the location of the 24 GHz transmitter and various thermal aspects.

On Monday, February 14, 1994, Konrad Hupfer (DJ1EE) arrived from Munich to discuss with Karl Meinzer and Werner Haas the progress of his 250 Watt Mode-U 70cm transmitter. Konrad Hupfer also took the opportunity to solve the associated thermal and mechanical aspects in the construction of flight and test versions. Important questions regarding the electrical interface were also clarified. On this occasion Werner Haas showed his first flight hardware consisting of two command receivers, a digital section and the 70cm exciter which will drive Konrad Hupfer's 70cm final amplifier stage in the satellite.

Receivers

From Tuesday, February 15 until Thursday, February 17, specific questions regarding the various receivers were addressed. Freddy de Guchteneire (ON6UG) and Dr. Matjaz Vidmar (S51MV) arrived to clarify the HF and digital interfaces between the front-ends and the remainder of the electronics as well as the power supply. Freddy, Matjaz, Werner, Karl and Peter jointly alloted the interfaces to the onboard computer along with the required control lines and connector pinouts of the modules. Werner Haas assisted Freddy and Matjaz in resolving questions with the HF units. Since Werner built the transponders and front-ends for OSCAR-10 and OSCAR-13, he is therefore very experienced in constructing flight-ready transponder hardware. Several technological questions were discussed, followed by an exchange of hardware and components. Freddy de Guchteneire reaffirmed that he will build the two 2m and 70cm receiver front-ends. Matjaz Vidmar stated that he will build the front-ends for 13cm, 5.6 GHz and 15m. If possible, all three or at least two receivers should be built into a single module and share a common IF output to the matrix. Depending on how fast he progresses, Matjaz could possibly accept additional assignments.

Dr. Mirek Kasal (OK2AQK) has already begun the construction of the Mode-L front-end and the second command receiver. He expects to deliver a prototype in May. His presence in Marburg was not required since he had already discussed the interface questions with Werner Haas. To emphasize the practical aspects, Freddy demonstrated his Mode-S equipment for OSCAR-13 on Tuesday evening at 23:00 local time. Using his 48cm parabolic antenna, relatively strong Mode-S signals were received through an open window in AMSAT-DL's laboratory. Directly attached to the Helix radiating element was a HEMT preamplifier, built according to the design by DJ9BV. (Refer to the article by Heinz Hildebrand, DL1CF, in the December '93 issue of AMSAT-DL Journal.) An Icom IC202 provided a 2m IF-stage following the home-built Mode-S converter. Among the stations that could be readily received was Joe Flaska (WB0RLY) who was still well remembered by several participants who attended the integration of AO-13 in Denver, Colorado. His home-made hamburgers and Mexican beans were simply super!

All hardware developers had extensive opportunity to clarify with Dick Jansson the mechanical aspects of their modules and to accept flight module cases from him.

Conclusion

For all participants, the meeting in Marburg was very intensive but judging from the results also very successful. The meeting brought forth new impetus and new motivation for the joint P3D project. Dr. Karl Meinzer, project leader for AMSAT P3D expressed his sincere appreciation to all participants for their commitment to this international satellite project.

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AMSAT Software Library

by Roy Welch, WØSL, AMSAT Software Library Manager

TRACKING PROGRAMS

ORBITS II - For IBM-PC or compatibles. Requirements are 512k RAM, one 5 1/4 floppy drive, DOS 2.0 or later and CGA adapter and monitor. Features include: (1) Real-time tracking in either a tabulated mode or a graphics presentation of a world map upon which the satellites are moved. Up to nine satellites can be tracked simultaneously in each satellite file. There is a maximum of eight files possible. In the map mode a single satellite can be selected and a footprint will be drawn around that satellite while the others continue to be moved. (2) Automatic control of azimuth and elevation rotators in either foreground or background modes using the Kansas City Tracker interface standard. (3) Batch output to screen, printer or disk for a single satellite for selected periods and update intervals. (4) Keplerian Elements can be entered manually or automatically from a text file in AMSAT or NASA two line format. (5) Ground station data is entered by following program prompts. (6) Output includes satellite azimuth, elevation, height, range, latitude, longitude, mean anomaly (0-255), Doppler shift and pointing angle. (7) All menu driven with extensive prompts and error routines to protect against invalid input. Operating instructions are contained in a text file which can be printed by the user. $30 members; $50 non-members; $150 commercial.

ORBITS III - For IBM-PC and compatibles. Functionally identical to ORBITS II above but is designed for use with EGA or VGA adapters and monitors. Graphics are more detailed than in ORBITS II. Requires 512k RAM, one 5 1/4 floppy drive, DOS 2.0 or later and EGA or VGA adapter and monitor. $40 members; $60 non-members; $175 commercial.

QUIKTRAK 4.0 - For IBM-PC and compatibles. Requires DOS 3.0 or later. Requires 512k for CGA graphics but needs 640k for VGA-EGA. No math coprocessor required but will run much faster with one. Features include: (1) User selected EGA-VGA or CGA graphics. For single satellite tracking mode, two scale factors are supplied: (a) the whole world, and (b) one level of magnification around the satellite position. A second graphics mode displays multiple satellites on a world map. In the single satellite graphics mode, you can also display the satellite footprint, the Sun line, the satellite groundtrack and all pertinent numeric data. (2) Real-time tabular data for multiple satellite visibility from your QTH. (3) Real-time tabular data for one satellite to your QTH and multiple other locations from the CITIES file. (4) Displays equator crossing data or apogee times and location. (5) Visible satellite (MIR, space shuttle, etc.) Search and Track features for visible observation. (6) Window Search to permit choosing two of 101 cities to find mutual visibility windows. (7) Enhanced Auto Tracking to include multi-satellite functions, both tabular and graphic. Uses Kansas City Tracker interface standards. (8) Choose between Mean Anomaly measured in degrees and Orbit Phase for display in the real-time tracking function. (9) Includes display of Off Pointing Angle. $50 members; $70 non-members; $200 commercial.

INSTANTTRACK - For IBM-PC or compatibles. Requires 512k RAM. Any type display ok for text screens but VGA preferred. Graphics screens require EGA or VGA display. A math coprocessor is not required but is recommended. A mouse is not required, but can be used on map screens. Features include: (1) Instant visibility. Shows the position of your favorite satellites before your first key stroke. (2) Real-Time displays. Includes azimuth, elevation, range, Doppler shift, path loss, squint angle, sub-satellite position (in latitude/longitude, grid square, and nearest city), Cartesian coordinates of observer and satellite, satellite rise/set time, satellite mode, Right Ascension, Declination, sky temperature, and more. (2) Full color high resolution maps of the Earth, showing satellite and observer's position, two kinds of satellite footprint, gray-line, etc. User can also select either a diagram of the satellite's orbit showing its orientation, or a map of the sky, showing the satellite's position against a star field. (3) Automated Keplerian element update using AMSAT and NASA format text files. (4) You can be shown schedules such as the next three weeks for a satellite or one day for 20 satellites on one screen. (5) A unique background mode allows you to track satellites and control antenna rotators in real-time while you run other programs. (6) Tracks the Sun and Moon as well as the satellites in the data base. (7) Automated time setting of your computer by accessing the NIST (formerly NBS) time service via your modem. (8) Supports a database of 200 satellites and 50 observer locations. (9) Includes a database of 1754 cities worldwide. (10) Observing stations can be specified by entering as little as their city name or their grid square. (11) Shows when satellites can see each other and when they are in eclipse in real-time. (12) Squint (off pointing) angle shown to indicate how far off from you the satellite's antennas are pointed. (13) Path loss between observers and the satellite is calculated. (14) Computes the time at which a satellite will rise without the delay of stepping through small time increments between now and then. (15) Can display the tracking parameters for both your perspective and that of another station, perhaps the one you are working. (16) Extensive and tutorial documentation is included with the program. (17) Online help can be obtained from almost any screen. $50 members; $70 non-members; $200 commercial

SATELLITE PRO - For the Macintosh, this program requires 1 Mb or more of memory and a double-sided (800k) disk drive. Printers supported include the Apple LaserWriter, ImageWriter (except LQ), and GCC Personal LaserPrinter. The four modes of Satellite Pro, LOCATE, TRACK, SCHEDULE and WINDOW combine with five graphic display options, RECTANGULAR, POLAR, GREAT-CIRCLE, PERSPECTIVE and VIEW from SPACE to satisfy almost any imaginable requirement. LOCATE mode provides a quick look at the current status of one or more satellites either by tabular data or by one of the several graphic options. The Satellite Pro database can hold orbital elements for up to 30 satellites. TRACK mode provides satellite positional data in steps from 0.001 minute to 60 minutes or in real time. Data includes latitude, longitude, altitude, elevation, azimuth, range, Doppler shift, orbit phase, orbit number and squint angle. If a graphic display is selected, the position and coverage area of the satellite will be shown. Options in the TRACK mode include display of the ground track as well as overlaying successive coverage footprints. SCHEDULE mode will produce a timetable showing the rising and setting times for the selected satellite for a given day. The maximum elevation angle and time of occurrence during each pass is also shown. WINDOW mode provides tracking data during the common time that the satellite is visible from the observer's and another location. The Satellite Pro database can hold information for up to 20 additional locations. $50 members, $70 non-members.

QUIKTRAK (NO GRAPHICS) - For IBM-PC or compatibles that do not have graphics capabilities (See APPLE QUIKTRAK). $25 members, $35 non-members.

C-64 SUPERTRAC - For C-64 Commodore. A combination of QUIKTRAK (just above) and enhanced graphics with excellent scheduling flexibility. Disk only. $30 members; $40 non-members.

C-128 ORBITS - For C-128 Commodore. No graphics. Requires an 80 column monitor and a Commodore compatible printer. Makes specific use of the unique capabilities of the C-128. Uses time based incrementing with user-selected time increments. Features automatic page formatting and pagination. As many as 20 satellites may be entered into the Keplerian element files. $30 members; $40 non-members.

AMIGA ORBITS - For the AMIGA operating in the 80 column mode. Requires 256k RAM and AMIGA supported printer. Translated to AmigaBasic. Runs under Workbench V1.2, V1.3 or 2.0. Has same features as C-128 ORBITS but runs considerably faster. Has provision for mode and phase programming to alert users to which satellite transponder is active. 3 1/2 inch disk. $30 members; $40 non-members.

APPLE QUIKTRAK - For Apple II. A menu driven program. Requires an 80 column card and 64k RAM. Incorporates a very fast algorithm for finding usable passes for the satellite of your choice. Satellite pointing angle relative to your QTH and a "window track" mode are included. The "window track" feature identifies mutual windows between your QTH and other specified locations. Includes menu driven utilities for data entry. $25 for members; $35 non-members.

C-TRACK 1 - For Tandy Color Computer 2 and 3. Requires 32k RAM, floppy disk drive and monitor. Uses CoCo 2 screen. Features include text-based output to screen, printer or disk file. Utility for automatic conversion of AMSAT format Keplerian elements to disk file. 100 satellite database. $25 members; $35 non-members.

C-TRACK 2 - For Tandy Color Computer 3 only. Requires 128k RAM, floppy disk drive, B&W monitor. Same features as C-TRACK 1 plus the addition of graphics. Tracks satellite footprints over world map in realtime. Tracks one satellite at a time. Documentation is included on the diskette. $35 members; $45 non-members.

TRS 80 Model 4 QUIKTRAK (NO GRAPHICS) - This basic language program is an adaptation of the popular N4HY Apple QUIKTRAK program. The program is menu driven and supports tracking and schedule functions for 14 different satellites. Satellite pointing angles relative to your QTH and a "window track feature" which identifies mutual "windows" between your QTH and other specified locations around the world are incorporated in this program. Also included is a BASIC program for automatically updating the Keplerian elements from a text file in the NASA two-line format. Full documentation is included as a file on the program disk. Program requires a TRS 80 Model 4 or 4P computer operating under TRSDOS 6.2 or later, dual disk drives and 64K of memory. $25 members; $35 non-members.

ATARI 8-BIT TRACKING PROGRAM - This program is the original W3IWI tracking program modified for the ATARI 8-bit series of computers. It runs in ATARI BASIC and has output capability to either screen or printer. No graphics. Documentation is included on the diskette. Requirements include ATARI 400, 800 with ATARI BASIC cartridge installed, ATARI 600XL, 800XL, 1200XL, 65XE or 130XE. ATARI 810 or 1050 disk drive or compatible. Printer is optional. $10 members; $20 non-members.

ATARI ST SATELLITE PREDICTION PROGRAM - A realtime display includes a graphic map of the world showing satellite location and footprint, latitude, longitude, altitude, azimuth, elevation, mean

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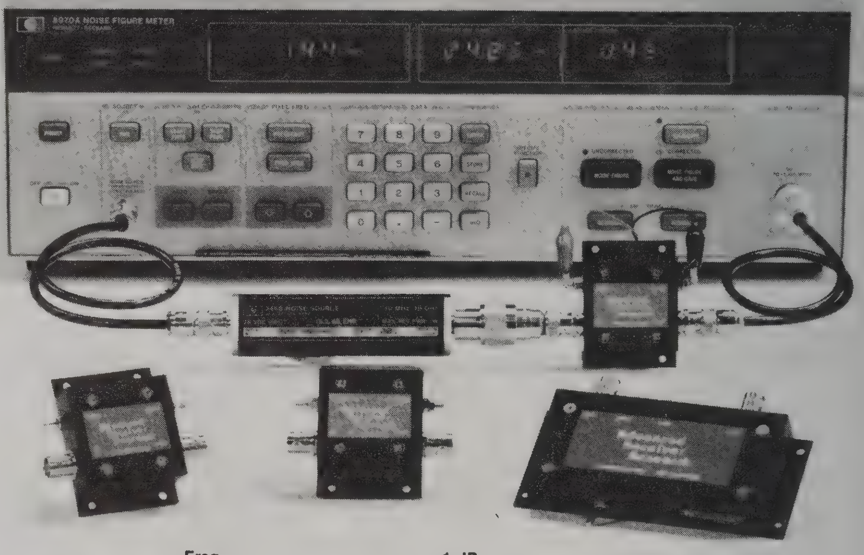

Receive Only	Freq. Range (MHz)	N.F. (dB)	Gain (dB)	1 dB Comp. (dBm)	Device Type	Price
P28VD	28-30	<1.1	15	0	DGFET	$29.95
P50VD	50-54	<1.3	15	0	DGFET	$29.95
P50VDG	50-54	<0.5	24	+12	GaAsFET	$79.95
P144VD	144-148	<1.5	15	0	DGFET	$29.95
P144VDA	144-148	<1.0	15	0	DGFET	$37.95
P144VDG	144-148	<0.5	24	+12	GaAsFET	$79.95
P220VD	220-225	<1.8	15	0	DGFET	$29.95
P220VDA	220-225	<1.2	15	0	DGFET	$37.95
P220VDG	220-225	<0.5	20	+12	GaAsFET	$79.95
P432VD	420-450	<1.8	15	−20	Bipolar	$32.95
P432VDA	420-450	<1.1	17	−20	Bipolar	$49.95
P432VDG	420-450	<0.5	16	+12	GaAsFET	$79.95
Inline (rf switched)						
SP28VD	28-30	<1.2	15	0	DGFET	$59.95
SP50VD	50-54	<1.4	15	0	DGFET	$59.95
SP50VDG	50-54	<0.55	24	+12	GaAsFET	$109.95
SP144VD	144-148	<1.6	15	0	DGFET	$59.95
SP144VDA	144-148	<1.1	15	0	DGFET	$67.95
SP144VDG	144-148	<0.55	24	+12	GaAsFET	$109.95
SP220VD	220-225	<1.9	15	0	DGFET	$59.95
SP220VDA	220-225	<1.3	15	0	DGFET	$67.95
SP220VDG	220-225	<0.55	20	+12	GaAsFET	$109.95
SP432VD	420-450	<1.9	15	−20	Bipolar	$62.95
SP432VDA	420-450	<1.2	17	−20	Bipolar	$79.95
SP432VDG	420-450	<0.55	16	+12	GaAsFET	$109.95

Every preamplifier is precision aligned on ARR's Hewlett Packard HP8970A/HP346A state-of-the-art noise figure meter. RX only preamplifiers are for receive applications only. Inline preamplifiers are rf switched (for use with transceivers) and handle 25 watts transmitter power. Mount inline preamplifiers between transceiver and power amplifier for high power applications. Other amateur, commercial and special preamplifiers available in the 1-1000 MHz range. Please include $2 shipping in U.S. and Canada. Connecticut residents add 7-½% sales tax. C.O.D. orders add $2. Air mail to foreign countries add 10%. Order your ARR Rx only or inline preamplifier today and start hearing like never before!

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anomaly, orbit number, velocity and relative velocity, range, Doppler shift and other items of information. Data can be stored for up to 150 satellites entered manually or automatically from a text file in NASA format. The program can display one or many satellites by stepping through one at a time. Set-up is customized by the use of default files. Other set-ups can be loaded in. Data print out for a specified satellite and time frame is provided. Requirements are 520k RAM memory, double sided 3.5 inch floppy drive and monochrome or color display. Supports math co-processor. $25 members, $35 non-members.

HP-41 PROGRAMMABLE CALCULATOR - ORBIT 1 - This program will output azimuth and elevation in real-time or all W3IWI parameters in a batch mode. Requirements: HP-41C + QUAD Memory, HP-41CV or HP- 41CX. Card reader very desirable but not essential.

ORBIT 2 - Same as ORBIT 1 plus the addition of functions from the Time Module for use during the real-time calculations. Please specify ORBIT 1 or ORBIT 2 for the HP-41. $25 members; $35 non-members.

STSORBIT PLUS - For IBM PC compatibles. This program is designed to track NASA Space Shuttles and other satellites. It displays the orbital position and projected ground track of the shuttle on a global map during a typical NASA mission. The display attempts to duplicate the wall map in NASA's Mission Control Center. NASA ground tracking stations and Tracking Data Relay Satellites are shown on the map if desired. When used with an EGA or VGA monitor, the display is in color. With CGA and HGC systems the display is presented in monochrome. Orbital data may be entered manually for space shuttle missions, but the NASA/NORAD two line Keplerian elements may be automatically used for all satellites as well as the space shuttle when available. Documentation is contained on the 3.5" diskette. Members and nonmembers $20.

TELEMETRY DECODING PROGRAMS

TLMDC II - For IBM-PC or compatibles. This program has a friendly user interface, file flexibility, the ability to save decoded data and a feature to alert the user when a value is beyond a set of limits. It decodes telemetry from the Microsats (AO-16, WO-18, LU-19 and DO-17) and displays the values in engineering units on the screen. It will also save raw KISS data, ASCII data or the engineering units in files which can be printed later or imported into spread sheets. Files saved with this or other communications programs can also be read in and decoded later. Extensive documentation is included on the diskette. $20 members; $30 non-members.

AO-13 PSK TELEMETERY DECODING - For IBM-PC or compatible. No graphics required. Requires serial port and the G3RUH demodulator. Decoded data sent to screen, printer or disk file. Documentation and telemetry information on disk. $35 members; $45 non-members.

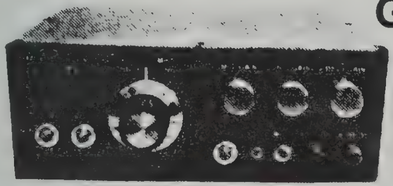
FO-20 TLM V1.0 - For Macintosh. This program decodes telemetry from FO-20 that has been recorded to a TEXT file on a Mac. The TEXT file can be created by many terminal programs. Will save the decoded data to a file, and will also print it. Includes a User Guide document. Comes on a single 800K disk. Requires Mac Plus or higher. The ground station must be equipped with a PSK modem associated with a Packet Radio TNC. Members $15, nonmembers $25.

UoSAT DATA CAPTURE AND DISPLAY PROGRAM - For Commodore C-64. This program is a 1200 bps ASCII terminal program designed for reception and storage of digital transmissions made by UoSAT-1 (OSCAR-9) and UoSAT-2 (OSCAR-11) written in high speed machine language. This user friendly program also has the capability for decoding DCE (Digital Communications Experiment) transmissions. The program features saving/loading received data to a floppy disk, printing received data and displaying the disk directory. Requires a floppy disk drive, a video monitor, and a 1200 bps demodulator. Documentation includes a schematic of a low cost, easy to build demodulator. The decoding chip for this demodulator is available from AMSAT as an option to the program. Program $25 members; $35 non-members; Demodulator chip $5 extra.

OTHER PROGRAMS

WEBERWARE - For IBM-PC or compatibles. Processes and displays pictures of the Earth transmitted from Webersat (WO-18). It assists in merging several raw data files to fill in a complete picture. While the highest resolution is in black and white, routines are provided to add color for CGA or EGA displays. Information is given on how to modify the files for display on some standard VGA displays. Routines are provided that permit changes in contrast, brightness and color pallet. Zoom and viewed aspect change capabilities are provided. Requirements include DOS 2.0 or later, graphics display and two floppy drives. A hard drive and math coprocessor are recommended but not required. The user ground station must be equipped with a PSK modem associated with a Packet Radio TNC which can be put into the KISS mode. Members $30; non-members $50.

KEP/LOADER V2.5 - For Macintosh. This program automatically updates Keplerian elements for use with the Satellite Pro tracking program. It accepts either NASA or AMSAT format Keplerian data files and updates the file used by Satellite Helper. Only those satellites for which there are more recent elements than those already in Satellite



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Current Amateur Satellite Frequencies

Satellite	Callisgn	Uplink	Downlink	Type
AO-10		435.03-435.18 LSB/CW	145.975-145.825 USB/CW	Mode B Analog
AO-13		435.423-435.573 LSB/CW	145.975-145.825 USB/CW	Mode B Analog
AO-13		435.602-435.606 USB/CW	2400.715-2400.749 USB/CW	Mode S Analog
FO-20		145.9-146.0 LSB/CW	435.9-435.8	Mode J Analog
AO-27		145.85 FM	436.80 FM	Part-Time Repeater
AO-21		435.016 FM	145.987 FM	Part-Time Repeater
RS-10		145.865-145.905 USB/CW	29.360 - 29.400	Mode A Analog
RS-12		21.21-21.25 USB/CW	29.41-29.4	Mode K Analog
AO-16	PACSAT	145.90, .92, .94, .96 FM	437.0513 USB	1200 Baud PSK
DO-17			145.825 FM	1200 Baud AFSK/ voice
WO-18			437.104 USB	1200 Baud PSK (img)
LO-19	LUSAT	145.84,.86,.88,.90 FM	437.1258 USB	1200 Baud PSK
FO-20	8J1JBS	145.85,.87,.89,.91 FM	435.91 USB	1200 Baud PSK
UO-22	UOSAT5	145.9, .975 FM	435.12 FM	9600 Baud FSK
KO-23	HL01	145.85, .90 FM	435.175 FM	9600 Baud FSK
KO-25	HL02	145.98 FM	436.5 FM	9600 Baud FSK
IO-26	ITMSAT	145.875, .90, .925., 95 FM	435.822 USB	1200 Baud PSK
POSAT	POSAT1	145.975 FM	435.2777 FM	9600 Baud FSK

1) Frequencies shown are without doppler compensation. For typical digital satellite pass the original signal will be about 8 kHz higher than what is shown.

2) WO-18 Webersat transmits experimental and image data and can be captured in KISS mode via PB or TLMDC.

3) Except for FO-20 the digital sats use a program suite containing PB/PG/PFHADD/PHS. The broadcast callsign (in PB.CFG) is the satellite's callsign with an SSID of -11. The connected mode callsign (in PG.CFG) is the satellite's callsign with an SSID of -12.

4) When in mode JD, FO-20 can be worked with any packet program. Connect to 8J1JBS. FO-20 currently alternates between modes JA and JD on a weekly basis. Check ANS bulletins for schedule.

5) AO-10 is no longer controllable but the transponder works when the satellite is in sunlight.

6) For AO-10 and AO-13, transmit LSB, receive USB. As transmitted frequency is increased the received frequency will decrease (inverting transponder).

7) AO-21 currently operates on a 10 minute schedule with FM repeater, WEFAX image transmission, and 1200 baud AFSK telemetry in each cycle.

Helper are updated. Requires a Mac Plus or higher. Members $10, nonmembers $20.

UP/DOWN - A For IBM-PC or compatibles. UpDown is an Amateur Radio Satellite Operations Aid program. It provides Uplink to Downlink frequency conversions, technical data, history, beacon frequencies, modes available, and other useful information about the satellite. Provisions are included for the user to update the satellite information as he sees fit. There are actually 3 versions of this program supplied on the disk. They are called UpDown2, UpDnWin1, and MinUpDn1. UpDown2 runs under DOS and is useful for laptop operation, UpDnWin1 is a full screen, more capable, program and runs under Windows, and MinUpDn1 is a smaller Windows version to enable the concurrent display of other programs. With MinUpDn1, it is possible to display both a tracking program like InstantTrack and a Frequncy Program. It is written to run in an IBM compatible computer equipped with EGA or VGA graphics in color. For the operator just getting started in Amateur Radio Satellites, this program provides a ready reference for valuable information about all of the birds in one convenient place. Members & non-members $15.

INSTANTTRACK UTILITIES - A disk of utility programs for the IBM-PC or compatibles. IT users will find some very useful. Pacsat users will appreciate the two KISS related files. The disk contains the following: ITPASS - Outputs a table of upcoming passes with AOS, LOS and maximum EL. ITSORT - Rearranges IT's satellite database using your own text editor. ITSTAMP - Adds AZ/EL/RANGE to a timestamped ASCII log file. DISPANG - Displays OrbitDRV antenna angles in upper right corner of screen. IMPDRV - IT-compatible RotorDRV for the WB5IPM controller from QEX (N5BF). DUMMYKCT.ZIP - Assembly language source for the dummy RotorDRV. DRVSVC.DOC - Specification for the Kansas City Tracker software interface. KCTHW.TXT - Reverse-engineered hardware data on the Kansas City Tracker. KISS2ASC - Converts a KISS binary log file to readable ASCII. KISSFILT - Selectively filters a KISS log file by callsigns, etc. Members & non-members $15 MICROSAT BBS PROGRAMS - For IBM-PC or compatibles. There are a suite of programs available for use in communicating with the Microsats. These programs are available with the PACSAT Beginner's Guide. Updates are available from the Microsat BBS.

SATCRCS - This program for IBM-PC

Satellite Orbital Elements

by Ray Hoad, WA5QGD

Satellite	AO-10	UO-11	RS-10/11	AO-13	FO-20	AO-21	RS-12/13
Catalog Num	14129	14781	18129	19216	20480	21087	21089
Epoch Time	94078.88849305	94080.50956311	94079.84948217	94079.56167208	94080.89109631	94080.39087956	94079.90823919
Element Set	271	675	883	896	670	446	673
Inclination	27.1881	97.7914	82.9229	57.8735	99.0243	82.9379	82.9180
RA of Node	336.3846	99.3260	34.1304	262.2374	249.2547	207.6619	76.9195
Eccentricity	0.6021341	0.0011137	0.0010237	0.7209738	0.0540894	0.0035401	0.0029938
Arg of Perigee	163.5017	186.0140	273.8387	337.3974	177.1640	331.2194	357.6064
MeanAnomaly	230.9609	174.0935	86.1598	2.4979	183.2749	28.7007	2.4956
Mean Motion	2.05878514	14.69174575	13.72333391	2.09727288	12.83224747	13.74536127	13.74037183
Decay Rate	-.00000143	.00000321	.00000032	-.00000427	-.00000016	.00000093	.00000032
Epoch Rev	8094	53743	33779	4415	19293	15752	15652
Satellite	**AO-16**	**DO-17**	**WO-18**	**LO-19**	**UO-22**	**KO-23**	**AO-27**
Catalog Num	20439	20440	20441	20442	21575	22077	22825
Epoch Time	94080.46187457	94080.42475274	94081.23816758	94080.24263321	94079.70081566	94080.53661719	94081.11877430
Element Set	775	774	776	774	476	371	272
Inclination	98.5999	98.5973	98.6015	98.6015	98.4399	66.0814	98.6600
RA of Node	167.5628	167.8190	168.6325	167.8834	155.9592	103.5014	157.7790
Eccentricity	0.0012341	0.0012406	0.0013015	0.0013223	0.0007223	0.0011679	0.0009554
Arg of Perigee	89.1267	88.5722	86.3234	87.9281	188.8493	308.7258	101.5696
MeanAnomaly	271.1308	271.6879	273.9433	272.3415	171.2552	51.2714	258.6548
Mean Motion	14.29886627	14.30025717	14.30001255	14.30095566	14.36900838	12.86285587	14.27613987
Decay Rate	.00000059	.00000076	.00000086	.00000078	.00000111	-.00000037	.00000025
Epoch Rev	21706	21707	21719	21706	14037	7551	2526
Satellite	**IO-26**	**KO-25**	**POSAT**	**MIR**	**MET-3/4**	**MET-3/5**	**MET-2/21**
Catalog Num	22826	22830	22829	16609	21232	21655	22782
Epoch Time	94081.10608673	94080.22548462	94081.13993678	94083.32520032	94080.99666993	94080.22430161	94080.53840969
Element Set	272	275	265	537	681	688	283
Inclination	98.6605	98.5601	98.6563	51.6456	82.5384	82.5573	82.5471
RA of Node	157.7921	155.1027	157.8404	251.6581	231.2188	178.8593	275.8954
Eccentricity	0.0009917	0.0012635	0.0011057	0.0015343	0.0014561	0.0014769	0.0023357
Arg of Perigee	100.6730	74.3234	89.9512	67.8161	45.1711	59.6601	108.2430
MeanAnomaly	259.5579	285.9328	270.2938	292.4504	315.0592	300.6003	252.1263
Mean Motion	14.27717009	14.28041738	14.28013136	15.58331750	13.16460562	13.16828445	13.83002864

or compatibles will read Keplerian element data files in either NASA 2-line or AMSAT format and verify it for accuracy before creating an AMSAT format output with AMSAT checksum value. It is designed to aid those users obtaining Keplerian elements from sources where the data may have been corrupted in route. It also filters out the headers of messages containing satellite Keplerian elements. The output file contains only verified and reliable elements. More than one input file can be written to the same output file, allowing you to append data from different satellites (i.e. OSCAR, MISC, WEATHER etc..) into a single output file. Members and non-members $15

VEC2TLE - This program for IBM-PC or compatibles provides the user with the capability to convert position/velocity/time state vectors of a variety of formats to National Aeronautics and Space Administration (NASA) Compatible Two-Line Element (TLE) sets. These element sets contain orbit descriptions compatible for propagation with the Simplified General Perturbations (SGP) and SGP Version 4 (SGP4) orbit theories developed for use by the North American Aerospace Defense Command (NORAD) and United States Space Command (USSPACECOM). Members and non-members $25.

Any of the software programs discussed above may be ordered directly from AMSAT Headquarters.

Heard on the Downlink

by John Hansen, WA0PTV

The Kansas City Tracker

The Kansas City Tracker is one of those venerable products that has been in the shacks of many satellite operators for quite some time. Its principal functions are to keep the antennas pointed at a satellite as it goes overhead and to tune the radio to adjust for changes in the Doppler shift (if it is equipped with the optional tuner). The tracker is an 8 bit PC card that occupies one slot.

The original software that came with the tracker/tuner has been much improved by Joe Barger N6KK. If you are using the tracker and have not upgraded to Joe's software, you really should. The latest version of his software is 5.11 which comes in a zip file that includes a program I wrote some years ago called SATSORT that allows you to load up a bunch of satellite passes into the TSR-loaded table and then sort them chronologically after the fact.

Buried in Joe's documentation for his software is a discussion of how he used the antenna switch feature of the KCtracker to switch the polarity of his downlink antenna based upon the strength of the signal from the bird. It was a clever system, but since my digital operation involves mostly the 9600 baud satellites, polarity switching was not a big issue for me (WD0E put out a bulletin a few months ago that explained that the antennas on those spacecraft are such that polarity switching is not an issue there).

I was, however, interested in using this mechanism to do other things when a satellite came above the horizon... such as connecting and disconnecting the TNC audio line to my 736. If you leave the audio connected from the TNC full time, very little audio is actually transmitted through the microphone. As a practical matter I always found it necessary to reach around disconnect the TNC in order to use the mic on the radio.

Another use for this type of switch was to use my station for automated 9600 baud forwarding when the satellite wasn't up. I run a packet BBS which forwards to Canada. The high gain satellite beam was just what the doctor ordered to make that jump so I rigged the tracker board to "park" the antenna so it was pointed at Canada when the digital satellites were not up. I used the antenna switch on the tracker board to switch all the audio lines between two TNC's. One was used for satellites, the other for the hop to Canada. Thus anytime the satellites were not up my station was available for forwarding. I wouldn't want to run a user port this way, but for forwarding it worked well.

Joe's documentation explained a mechanism for getting the Tracker to provide 12 volts when a tracked satellite came above the horizon but it involved cutting a trace or two on the original board and I really wanted to avoid that. However, five volts at low current is easily available on the board. Just to the right of the dip switches (if you hold the board with its pins down and bracket to the right) is a 20 pin IC which on my board is a 74LS273. There is a second 74LS273 right below it. On the chip just to the right of the dip switches run a line from pin 12 (that's 1 over from the pin in the top right corner looking at the parts side of the board) to empty pin on the DB-25 connector on the board. I used pin 2. Make sure you pick an unused pin and use a continuity tester to make sure you know which pin of the plug you are wiring to. Don't short the 5 volt line to ground. You can use a 5 volt reed relay (such as those available at Radio Shack) to run a switching circuit to control just about anything with this. I used the reed relay to trip a 12 volt line that ran a heavier duty dpdt relay that did the switching for me. An inelegant solution, but it worked quite well.

To get the Tracker to switch that 5 volt line when a satellite comes up, call up the tuner screen using the "hot" key you've defined and switch to the "change" function. Page through the satellites until you find the one you want (you can do this for just one satellite, a subset of satellites or all satellites) and when you get to a satellite for which you want 5 volts when it rises, put a 1 in the "antenna" field instead of a 0. That will do it for you.

LView

In the AMSAT News section of this issue you will find some information on how to obtain up-to-date images from the Clementine spacecraft that is currently mapping the moon from a lunar orbit. The most notable thing about this source for me was not the images themselves, but rather the image viewing software that was available from the anonymous FTP site clementine.s1.gov. In particular, one program called LVIEW, which is a Windows image-viewing program created by Leonardo Haddad Loureiro, blew my socks off. It runs quickly, and displays images in a range of formats, including direct display of compressed JPG images. It also has a fast JPG mode that allows you to quickly view a JPG image to see what is on it.

LVIEW's capabilities for image enhancement are excellent. You can fool with the brightness, contrast, colors, or a number of other parameters. In the case of the two Clementine images I downloaded this turned out to be essential since at first blush they appeared to be totally black. By lowering the contrast and increasing the brightness, however, I was able to clearly see the closeup views of the moon's craters. If your hardware will support it, this program will do 24 bit color presentations. It has the usual "slide-show" features as well.

One of the best parts about LVIEW is that it is freeware. It's not even shareware, it's totally free. If you are running Windows you really should get a copy of this program. It is available from the FTP site mentioned above or if you send me a formatted disk and postage paid mailer, I'll return a copy to you.

The Internet

I mentioned Internet access in this column a few months ago. In the 1992 AMSAT Space Symposium Proceedings, Tom Clark, W3IWI described AMSAT's use of the Internet and discussed some of the ways that AMSAT members with direct Internet access could get on. Much has changed in the year and a half since that paper was published and I still get a number of inquiries each month from individuals who want to get access to AMSAT via the Internet.

AMSAT sponsors three mailing lists on the Internet. The most widely subscribed is called amsat-bb and it is a general bulletin board and discussion group for matters relating to AMSAT, satellites, technology, and so forth. Anyone can post messages to amsat-bb. There are two other mailing lists as well, one to distribute AMSAT News Service bulletins and one to distribute Keplerian elements bulletins. These bulletins are all widely available on other sources (including packet radio) and as a result will probably be of less interest to you. However, these mailing lists are one of the principal ways that these bulletins get distributed to the outlets where you then access them directly.

The mailing list amsat-bb can be accessed from any e-mail outlet that has an Internet connection. This includes Compuserve, Genie, Delphi, and most other online services. However, you should be aware that getting on the mailing list will substantially increase the amount of e-mail you receive, so if you are paying for this bandwidth, it can amount to some money. I typically receive a half dozen amsat-bb items a day.

To subscribe to the amsat-bb mailing list, send a message to:

listserv@amsat.org

telling them you would like to subscribe to amsat-bb. The list is not automatically maintained, instead it is done by hand, so it may take a while to process subscribe/unsubscribe requests. Please be patient.

AMSAT currently has no repository for satellite related files, only an e-mailing list, though this option is under active consideration. There are a number of anonymous FTP sites around the world that do tend to carry a lot of ham radio stuff, including software. Two of the most popular of these are:

ftp.funet.fi in Finland,

and ucsd.edu in California

In addition another really good source that is less heavily used is:

oak.oakland.edu

Wayne Roth, WA2N, has recently uploaded his SATSKED program and some new JAMSAT trakbox firmware to this site.

If your only access to the Internet is via e-mail via Compuserve or some similar facility it is difficult, though not impossible to access FTP sites such as those mentioned above. It is not impossible, because of something called ftpmail which allows you to have files mailed to you. I've not used this capability and I suspect that using via Compuserve, for example, might become quite expensive rather quickly. That's one of the reasons that several months ago I mentioned Delphi in this space. Delphi advertises full Internet service at very reasonable prices. Until recently, however, I had not had the opportunity to try this out myself. However, a local ham, John Martinson, WB2WXN, obtained a Delphi account and asked me to drop by and test drive it on the Internet. I was quite impressed. Virtually every Internet service you might want, from e-mail to newsgroups, to ftp, to telnet, to finger was available through John's Delphi connection. John and I have tested the e-mail connection through Internet in both directions and it seems to work well.

Delphi has its own newsgroup reader which works quite well. There are, by the way, something like 8000 newsgroups on Internet concerning a wide variety of topics including satellites, several on amateur radio, various types of technology and almost anything else you can think of. Last night I noticed that a new newsgroup devoted to coffee drinking had been established. The first message on the group went to some pains to distinguish its purpose from other newsgroups devoted to beverages in general or to caffeine.

If you are not an Internet regular some of these terms may sound a bit foreign to you. Frankly, there is no substitute for going out and buying a good book that explains Internet services. One I've found that was quite good is The Internet Complete Reference by Harly Hahn and Rick Stout (Osborne). And no, they didn't send me a free copy.

I'm still not certain that I've figured out how much Internet through Delphi costs. The Delphi costs are very reasonable... 10 dollars a month for 4 hours of access or 20 dollars a month for 10 hours of access. However, when calling from here we ended up accessing Delphi through Tymnet which layers on its own charges. It wasn't clear to me that this was necessary; you may be able to get to Delphi directly. I live in a very rural area and absolutely none of the on line services have local access numbers, so it's always quite a game figuring out what the cheapest route in is. One of the reasons that I value my Internet connection through my employer so highly is that it is just about the only thing I can dial up for free.

F6FBB Satellite Tracking

You will notice a short article in this issue by Ray Soifer, W2RS on how to use the F6FBB BBS for satellite tracking. When I took over editorship of this publication last year a similar article was in the archives that I received from the previous editor. However, somewhere along the line it slipped between the cracks and disappeared. I do not know how long the article had been in the archives and I went to some lengths to try to find out where it was and who had written it. However, my efforts were unsuccessful, so I've printed Ray's version in this issue. If you are the person who wrote the original article, please drop me a note. And please accept my apoligies for not being able to locate the original version. It was, I'm afraid, a casualty of the editorial switch.

Satellite Frequencies Available Here

You will note that this issue of the Journal contains a new feature. Buzz Gorsky, Walt Daniel, and I have collaborated on a one page chart showing the frequencies and modes of all active amateur satellites. The purpose of this chart was not simply to show all the published frequencies for these satellites, but instead to show the frequencies on which they currently appear to be operating. Thus, it differs somewhat from what you may find in comprehensive public listings of their capabilities. We decided to put the chart in this issue because this issue of the AMSAT Journal will be distributed at Dayton and thus will reach a wide range of newcomers to our corner of the hobby. I would like to hear from you if you identify any errors in the chart. I would also like to know whether you think this feature should be carried every issue, every other issue, or every now and then.

There has been some discussion in the UK as to whether it is necessary or desirable to publish the Keplerian elements in their publications. The argument against publication is that this information is now so widely available from packet and telephone bulletin boards, that publication is no longer necessary. I'd like to hear what you have to say on this subject as well. I can be contacted at any of the follwing addresses:

Internet: waøptv@amsat.org Compuserve: 70353,460 U.S. Mail: 49 Maple Avenue, Fredonia, NY 14063

Vector to Two-Line Elements (VEC2TLE) Orbit Computation Software

by Ken Ernandes N2WWD

The VEC2TLE orbit computation software provides a means of computing very precise Keplerian Two-Line Elements (TLEs) for the Space Shuttle or any other satellite for which reliable position and velocity data is available. The primary inputs for this software are position and velocity orbital 'state vectors', which are obtained from several sources. VEC2TLE's ability to determine accurate Keplerian orbital elements in real-time makes it particularly attractive for Shuttle Amateur Radio Experiment (SAREX) applications.

Keplerian Element Compatibility

The Keplerian Elements output by VEC2TLE are in the standard NASA/NORAD TLE format. The TLE format is convenient since it may be read directly by all popular satellite tracking software. The Keplerian Elements computed by VEC2TLE are completely compatible with the orbit computation algorithms that use NASA/NORAD TLEs.

Shuttle Orbit Changes

The Space Shuttle differs from most spacecraft in that it has the ability to perform many significant orbital changes in its relatively short mission lifetime. The most significant changes to the orbit generally result from firings of the Shuttle's Orbital Maneuvering System (OMS) thrusters. (Minor orbital changes also result from the accumulated effects of things like: Reaction Control System [RCS] thruster firings, satellite deployments, and waste water dumps.)

Since a Keplerian TLE mathematically describes an orbit, its ability to predict future Shuttle positions depends on how accurately it models the Shuttle's orbit at any given time. As a result, a TLE generated prior to a significant orbit change may predict positions very accurately up to the time of a maneuver, but will experience a rapid and progressive degradation in its ability to predict the Shuttle's positions after the maneuver time. Accurate predictions after the maneuver time require a new TLE which reflects the Shuttle's post-maneuver orbit.

After an orbit change, a new TLE may not be available for the Shuttle for many hours. This is due mainly to the fact that public release of orbital data is a low priority task for U.S. Space Command. This is also due, to some extent, to the method by which orbit determinations [for external release] are made by Space Command. The Space Command orbit determinations use a mathematical process called a least-squares differential correction (DC), which computes the statistically most probable orbit for a satellite, based on tracking data. The accuracy of the DC process is limited by the accuracy and dispersion of the tracking data. Accurate orbit determination can be accomplished with a modest quantity and time span of very accurate tracking data; achieving equivalent accuracy using less reliable tracking data usually requires a significant increase in the data's quantity and time dispersion. The ultimate accuracy of the orbit determination will always be limited to some extent the quality of the tracking data.

Most of the radars available to Space Command had a primary mission of providing rapid warning of a ballistic missile attack. Because these don't need to be highly precise radars, it may take many hours of tracking data before Space Command can determine a highly precise TLE with the orbit determination (DC) process. In some cases an intermediate quality TLE is released earlier to facilitate radar tracking.

Orbit Determination Methods

NASA uses very sophisticated methods called Special Perturbations (SP) to maintain an extremely precise mathematical model of the Shuttle's orbit. While generally the most accurate and most flexible method of predicting satellite positions and velocities, its high computational burden makes it impractical for use on a Personal Computer (PC). The primary disadvantage to SP is the enormous computational overhead which results in very slow predictions in all but the most powerful computers. Other disadvantages include the need for an extensive database including real-time and historic solar and geomagnetic data.

The other commonly-used orbital computation method is called General Perturbations (GP). GP methods use relatively quick analytic orbit prediction methods in contrast to the arduous numerical integration employed by SP. The relatively fast prediction times for GP allow real-time computation of antenna pointing angles and frequency Doppler shift on even a modest computer. Furthermore, in the short-term (i.e., days) GP orbit predictions may be nearly as accurate as SP. In general, however, more current GP orbit determinations will provide more accurate satellite position predictions than older GP orbit determinations.

Perhaps the most popular GP algorithm is Space Command's Simplified General Perturbations Version 4 (SGP4) orbit propagator, since it is both accurate and fully compatible with the NASA/NORAD TLEs. In fact, Space Command uses SGP4 in the orbit determination (DC) process to generate these TLEs. It is for these reasons that most popular satellite tracking software uses SGP4 to compute satellite positions and velocities.

One significant disadvantage to SGP4 is that the Keplerian Elements in the TLEs are ficticious 'mean elements' rather than the physically representative 'osculating elements' [or state vectors] used by SP. (Osculating elements are the exact physical orbital parameters for any given instant of time.) Mean elements are similar to the osculating elements, but represent the mean values of the elements after the long and short periodic variations have been "averaged out". Because the mean and osculating elements are not exactly the same, using osculating elements in SGP4 will result in inaccurate orbital position and velocity predictions. Likewise, using mean elements in SP will also result in inaccurate orbital position and velocity predictions.

Shuttle SP Orbit Determination

NASA continually updates the SP trajectory determinations for the Shuttle using very accurate transponder beacon tracking [2217.5 or 2287.5 MHz] data. The Tracking and Data Relay Satellites (TDRS) perform the tracking of the Shuttle's transponder beacons. TDRS tracking is augmented with precise radar tracking data from the DOD C-Band Radar Network. Trajectory updates are accomplished by the Johnson Space Center (JSC) Mission Operations Computer (MOC) using a software process called an Extended Kalman Filter. The

Kalman Filter is an orbit correction process similar to a DC except that it runs continually and the position and velocity trajectory state is updated to the time of the most current tracking observation.

In addition to the very accurate tracking data provided to it, the fact that one of the MOC's primary tasks is to perform real-time SP orbit determinations for the Shuttle (and associated spacecraft) is the reason that frequent and accurate state vectors are available.

The Shuttle on-board inertial guidance computer also maintains an estimate of its position and velocity trajectory state using a Kalman Filter. The trajectory updates are performed using velocity changes sensed by the on-board accelerometers. These accelerometers can sense velocity changes due to thruster firings as well as minor effects. As a result, an update to the Shuttle's state vector can be available immediately after thruster cutoff for a maneuver.

The MOC monitors the Shuttle's inertial guidance system trajectory estimates. When the orbiter's trajectory estimate differs from that of the MOC by more than some defined threshold conditions, the MOC will upload a corrected position and velocity state vector to the Shuttle.
VEC2TLE Orbit Determination

VEC2TLE was designed to precisely convert real-time osculating SP orbital data to mean elements required for accurate SGP4 orbital predictions. VEC2TLE quickly computes mean Keplerian Elements that are fully compatible with SGP4. The accuracy of VEC2TLE's orbit determinations from NASA state vectors have proven to be at least as accurate as Space Command TLEs which, as previously mentioned, may require many hours of tracking data to compute.

VEC2TLE orbit determination is most easily accomplished by automatic read of a formatted state vector file. The file structure was designed to provide all the essential information necessary to construct a complete Keplerian TLE. The data is also labeled to provide information to the interested user. An example of a formatted state vector from the STS-58 mission is listed below:

Vector format = 117
Satellite Name: STS-58/SLS 2
Catalog Number: 22869 93 65 A
Epoch Date/Time: 93298.50065415509
10/25/1993 12:00:56.519 UTC
EFG E: 46257.24 ft
F: -19230538.32 ft
G: 10226886.33 ft
Edot: 20982.3731 ft/s
Fdot: 5729.8334 ft/s
Gdot: 10672.0622 ft/s
ndot/2 (drag): 0.00091203000 re/day^2
nddt/6: 0.00000E+00 rev/day^3
Bstar: 2.02000E-04 1/Earth Radii
Elset #: 18
Rev @ Epoch: 111.13401858113

Sources of Vector Data

State vector data for the Space Shuttle originates with NASA JSC MOC and/or the Shuttle Orbiter Vehicle (OV) inertial guidance system. State vectors originating from the MOC have been obtained from NASA JSC in Houston TX, NASA Goddard Spaceflight Center (GSFC) in Greenbelt MD, and the Marshall Space Flight Center (MSFC) in Huntsville AL. State vectors originating from the OV inertial guidance system have been obtained from the Rockwell Mission Support Room in Downey, CA.

I post formatted Shuttle state vectors embedded in messages on the CompuServe HamNet Forum and make this data available to the Sysops of the AMSAT Network BBSs. The vector data is also posted on some packet nodes. You are encouraged to re-distribute the vector data to any national or local BBS or packet network. Beginning with STS-61, NASA OIG RAID RBBS (301) 262-6784, located at GSFC, has been posting state vector data for the Space Shuttle. These vectors are in the Earth-Centered Inertial (ECI) True Equator True Equinox of Date coordinate frame (see Technical Details) with vector units of km and km/sec. At the time of this writing, this data was not formatted for direct read by VEC2TLE. This is expected to change in the near future. Access to NASA OIG RAID RBBS may be obtained by written request to:

NASA / Goddard Space Flight Center
Project Operations Branch / Code 513
Attn: Orbital Information Group (OIG)
Greenbelt, MD 20771
USA

Additionally, Shuttle vector data is also periodically posted by JSC on NASA Spacelink BBS (205) 895-0028, located at the MSFC. These vectors are in the ECI Mean of 1950 (M50) coordinate frame (see Technical Details) with vector units of ft and ft/sec. These vectors are not formatted to be directly read by VEC2TLE. Therefore, the data must be manually entered in order to compute the Keplerian Elements.

Users who manually enter vector data are cautioned to ensure that all VEC2TLE settings are consistent with the vector data. Further information is provided under the Technical Details heading.

Atmospheric Drag

Atmospheric drag can be the largest natural change to the orbits of satellites below 300 kilometers in altitude (for which having a reasonable drag parameter can be as important as the Keplerian Elements). The effects of drag are mesureable for almost all satellites below 800 km in altitude. Unfortunately drag can be difficult to forecast since it depends on the density of the upper atmosphere, which is highly dependent on the past, current, and future levels of solar activity.

Drag tends to be highest for satellites in lower altitude orbits and with high area to mass ratios. The atmosphere is thickest at lower altitudes and becomes thinner as altitude increases. Higher atmospheric density provides higher drag. Higher drag also occurs on satellites with higher cross-sectional areas and lower masses. A good analogy of the area to mass ratio is to consider of the drag effects if you were to throw a balloon and a bowling ball with equal force. Clearly the drag effects on the balloon (with a high area to mass ratio) are such that it slows down much more quickly than the bowling ball (with a low area to mass ratio). Neither the cross-sectional area nor the mass of the Shuttle is constant. The Shuttle's orbital cross-sectional area changes when it reorients itself on orbit. There are three major orbital orientations which each have a different cross-sectional area: 1250 sq. ft., 2500 sq. ft., and 4000 sq. ft. The Shuttle's mass changes due to things like satellite deployments/retrievals, fuel expended during thruster firings, and waste water dumps. The Shuttle's on-orbit mass (equivalent Earth weight) may vary between 180,000 and 250,000 lb during any mission.

Generally the best drag parameters to use in VEC2TLE are those used in the most recent Space Command TLE. These are determined empirically by the measured drag effects to the orbit in the orbit determination (DC) process. Attempts to develop a drag model internal to VEC2TLE have thus far only had modest success.

When VEC2TLE Should be Used

VEC2TLE was designed to compute Keplerian TLEs when state vectors are the most current orbital information available. VEC2TLE is most useful when a state vector is the only orbital information available following an orbit-adjusting thruster firing. You can, however, expect to realize some prediction accuracy benefit any time state vector information is more current than other orbital information. Generally, the greater the difference in epoch time between the old TLE and new state vector, the greater the accuracy benefit. This is particulary true for satellites which are experiencing relatively high drag effects.

Why Not Just Release the TLEs?

Perhaps the question I am most often asked is why don't I simply release the VEC2TLE-generated TLEs. I have four compelling reasons why I don't usually do this. These are:

Data Source Identification

TLEs generated by VEC2TLE can be impossible to distinguish from those released by NASA or other sources. In fact, there have been instances where VEC2TLE's Keplerian Elements have been misidentified as originating from Space Command/NASA. If the formatted vector data is provided instead of the TLEs, there is no question that the resulting TLE was computed from a NASA State Vector by VEC2TLE.

Ability to Edit Parameters

VEC2TLE generally requires that the user provide at least one of the two primary drag parameters (ndot/2 or Bstar). There have been instances when a Space Command/NASA TLE has been released at approximately the same time as my posting of a state vector. Very often, the 'new' TLE has an epoch time older than the post-ed state vector (but has the most current drag values). In such instances, the end-user can update the state vector with the new TLE's drag parameters, yielding the most current overall Keplerian TLE information.

Educational Benefits

In addition to providing timely orbital data, VEC2TLE was designed to be (and is) an educational tool. The best way to facilitate its use in this regard is to make the software and vector data as readily available as possible. Making the TLE data more readily available than the vector data tends to discourage the educational use of VEC2TLE.

Additional Sources of State Vectors

As time goes on, I am hopeful that additional sources of state vectors will become available for both the Shuttle and other satellites. This can only become a reality if use of VEC2TLE becomes widespread. As with the educational benefits, use of VEC2TLE will probably only become widespread if there are a significant number of instances where the vector data is the most currently-available orbital information.

Technical Details

This section is an overview for the technically curious.

From the physical laws of orbital mechanics, it can be shown that given the six independent Keplerian orbital elements at a specified [epoch] time, the position and velocity of the orbiting object can be computed for any other time. This process is referred to as orbit propagation.

The three vector components of position and three vector components of velocity also provide a complete description of the orbit. The function of VEC2TLE is to do the reverse of orbit propagation: determine the six independent Keplerian Elements corresponding to the position and velocity vectors.

If satellites orbiting the Earth did so with perfect Keplerian motion, both orbit propagation and the reverse (i.e., VEC2TLE) would be relatively simple. One set of Keplerian Elements would be sufficient to specify the orbit, and these parameters would predict the positions and velocities indefinitely. Likewise, this one set of Keplerian Elements could be computed, for example, from any one measurement of orbital position and velocity (provided that the measurements were exact).

The "real world" is not nearly this simple. We neither have perfect Keplerian motion, nor can we make exact measurements of the satellite's position and/or velocity. The imperfection in the Keplerian motion is due to natural disturbing forces on the satellite such as atmospheric drag, the slightly non-spherical mass distribution of the Earth, and the gravitational attraction of the Sun, Moon, and the planets. These disturbing forces are known as perturbations. Both GP and SP model significant orbital perturbations; SP does so more rigorously than GP. The inexactness of measurement in tracking data, as discussed earlier, dictates the quantity and time distribution of these data generally required such that the orbit determination (DC) process can statistically "average out" the error and compute a precise set of Keplerian Elements.

The effects of the small imperfections in orbit determination are realtively insignificant in the short term. Therefore perturbation modeling in the short term is excellent for both GP and SP. However, in the intermediate to long term, the ability of an orbit determination to accurately predict the satellite's positions and velocities deteriorates (GP more quickly than SP). Thus the satellite must be tracked continually and new orbit determinations must be accomplished at least periodically in order to maintain prediction accuracy. Space Command performs these orbital updates for all (7,000+) Earth-orbiting satellites; NASA does so for the Shuttle and other spacecraft under their control.

Position and velocity state vectors provided by NASA are typically in one of three cartesian coordinate frames: Earth-Centered Inertial (ECI) Mean of 1950 (M50), ECI True Equator, True Equinox of date, and Earth-Fixed Greenwich (EFG).

All three of these coordinate frames use the center of the Earth as the origin and the Earth's equator as the fundamental plane (i.e., the plane in which the first two coordinate axes lie). The principal direction (i.e., the direction of the first coordinate axis) is the Vernal Equinox for the ECI coordinate frames and the Greenwich Prime Meridian (GPM) for the EFG coordinate frame. (The Vernal Equinox is the direction for the Sun at the beginning of Spring.) When manually entering a vector into VEC2TLE, you must specify in which of the three coordinate frames the vector is referenced.

The M50 and True Equator, True Equinox of Date are two distinct ECI coordinate frames. The M50 represents the orientation of the Earth's equator and the Vernal Equinox at approximately the beginning of the year 1950. The True Equator, True Equinox of Date is referenced to the orientation of the Earth's equator and the Vernal Equinox at any specified time of interest.

While the orientation of the Earth's equator and the direction of the Vernal Equinox are nearly stationary (i.e., inertial), they do change over long periods of time. The change is mainly due to the effects of precession and nutation caused by the Sun, Moon, and other planets. Precession is the slow conical motion of the Earth's rotational axis; a process which takes about 26,000 years to make one complete gyration. Nutation is the wobbling motion of the Earth's equator; a process which takes about 18.6 years to make one complete cycle. The effects of precession and nutation are taken into account automatically by VEC2TLE.

Since the first two axes of the EFG coordinate frame rotate with the Earth, this is sometimes referred to as the True of Day Rotating (TDR) system. Since the EFG coordinate frame is rotating with the Earth, the velocity vector represents the velocity of the satellite relative to the Earth. In most cases a portion of the velocity is either masked or enhanced by the Earth's rotational velocity. This means that the EFG velocity is generally somewhat slower or faster than the inertial (i.e., ECI) velocity. This is known as the Coriolis effect. The Coriolis effect is accounted for automatically by VEC2TLE.

VEC2TLE can accept state vectors in three different sets of dimensional units: km, km/s; nm, nm/s; and ft, ft/s. NASA generally uses the ft, ft/s or km, km/s units. Since VEC2TLE also handles the dimensional conversions internally, a user making manual input of a state vector only needs to specify the vector's units.

Glossary

AMSAT	Radio Amateur Satellite Corporation
ARRL	American Radio Relay League
BBS	Bulletin Board System
DC	Differential Correction
DOD	Department of Defense
ECI	Earth-Centered Inertial
EFG	Earth-Fixed Greenwich
ft	Feet
GP	General Perturbations
GPM	Greenwich Prime Meridian
GSFC	Goddard Space Flight Center
JSC	Johnson Space Center
km	Kilometers
LEO	Low Earth Orbit
MOC	Mission Operations Computer
MSFC	Marshall Space Flight Center
M50	Mean of 1950
NASA	National Aeronautics and Space Administration
nm	Nautical Miles
OIG	Orbital Information Group
OMS	Orbital Maneuvering System
OV	Orbiter Vehicle
PC	Personal Computer
RAID	Reports and Information Dissemination
RBBS	Remote BBS
RCS	Reaction Control System
SAREX	Shuttle Amateur Radio Experiment
sec	Seconds
SGP4	Simplified General Perturbations Version 4
SP	Special Perturbations
STS	Space Transportation System
TDR	True of Day Rotating
TDRS	Tracking and Data Relay Satellite
TLE	Two-Line Elements
VEC2TLE	Vector to TLE

New converters for OSCAR & ARSENE

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Based upon the requests of the advanced satellite user, we have developed a new "easy to use" converter with these features:

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Fax ++49 / 23 71 / 6 75 93
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Mountaintop, PA 18707, USA
Phone ++1 / 717 / 868-5643
Fax ++1 / 717 / 868-6917
AMERICA, AUSTRALIA

The F6FBB Packet BBS Satellite Tracker

by Ray Soifer, W2RS

Have you (or a friend) ever wanted to try connecting to Space Station MIR or listening for RS12, but couldn't find out when the satellites would be in range or where to point your antenna?

If you have packet radio capability (even a TNC and a dumb terminal), you're probably in luck! Most packet bulletin boards which run the F6FBB BBS software are capable of tracking OSCARs, and all other satellites for which AMSAT puts out Keplerian elements, for you, producing times and beam headings for your QTH, and in English, no less.

To make use of this feature, follow these step-by-step instructions:

1. Log onto your local F6FBB packet BBS.

2. On your first check-in, you may be prompted for your Maidenhead grid square (e.g., FN20WW). If you never entered your grid square, or you're not sure if you did, enter it now with the command NL (e.g., NL FN20WW). If you don't know your grid square, the BBS can calculate it for you from your latitude and longitude (see below). Once entered, this information will be stored for later use; the BBS uses your grid square to compute satellite tracking data as well as for various other functions.

3. Enter the BBS's file-server mode with the command F.

4. If you want the BBS to calculate your grid square, enter Q and answer the prompts with your latitude and longitude. Then leave server mode (F) and enter your grid square into the BBS using the command NL. Return to server mode with the F command. If you've previously entered your grid square, you may skip Step 4 and proceed directly to Step 5 below.

5. Enter satellite mode with the command T.

6. At the next prompt, enter T again (for Tracking).

7. The next prompt will ask you to choose the satellite you want to track. This is done by number from a menu, which is pulled up with the command L (for List). Once you have your satellite's menu number, enter it when prompted.

8. You will now be asked for the starting date and time of your desired predictions. Enter these European-style, DD/MM/YY and 23:59 UTC.

9. The BBS will now give you dates, times and beam headings (azimuth and elevation) for the satellite of your choice. Capture these to disk, print them out using your communications program, or (if you're using a dumb terminal) write fast!

10. When you've seen enough, at the next prompt enter A (for Abort) or N (for Next) to try another satellite. When you're all done, follow the A command at the next prompt with F (for Finished).

11. Leave server mode with the command F and log off the BBS as usual.

Especially for active operators, the F6FBB packet BBS satellite-tracking routine is no substitute for the user-friendliness, convenience and features of a good tracking program. However, it does provide the essentials and it's readily available to every radio amateur with packet capability. Furthermore, it is quite accurate. The Keplerian elements upon which the tracking is based are automatically updated every time a new elements are forwarded to the bbs. This is an especially useful feature when you are attempting to track space shuttle orbits.

The next time any of your non-satellite oriented friends ask "when do I listen," now you can show them how to find out themselves!

AMSAT News

AMSAT Telephone BBS Update

John Wisniowski, N6DBF, The AMSAT-NA BBS Coordinator reports that the AMSAT-NA BBS Network now includes the following BBS's.

CompuServe's HAMNET Phone: (Local Access) Location: USA Baud Rate: Up To 14,400bps Sysop: Scott Loftness (W3VS)

Western Pacific Database Phone: 415-453-2854 Location: San Rafael, CA Baud Rate: Up to 14,400bps V.32bis Sysop: Daniel C. Dufficy (KH8AF)

The ARRL BBS Phone: 203-666-0578 Location: Newington, CT Baud Rate: Up To 14,400bps Sysop: Luck Hurder (KY1T)

California Amateur Radio Emergency Services (CARES) Phone: 916-323-4826 Location: Sacramento, CA Sysop: Gorden Fuller (WB6OVH)

AMSAT Sats & Stats BBS Phone: 201-261-2780 Location: New Milford, New Jersey Baud Rate: Up to 14,400bps Sysop: Mel Roman (KA2UPD)

HAM>LINK<RBBS Phone: 612-426-0000 Location: St. Paul, Minnesota Baud Rate: Up to 9600bps V.32 Sysop: John Desmond (K0TG)

OCA/AMSAT BBS Phone: 714-738-4331 Location: Fullerton, CA Baud Rate: Up to 24000bps Sysop: John Wisniowski (N6DBF)

DRIG BBS Phone: 214-394-7438 Location: Carrolton, TX Baud Rate: Up To 14,400bps Sysop: Jeff Wallach (N5ITU)

GEnie's Radio, Electronics, & Broadcasting RoundTable Phone: Call 800-638-9638 for information and local access phone number Location: USA Baud Rate: Up To 9600bps Sysop: Larry Ledlow (NA5E)

PC-Ham (Reliable) BBS Phone: 301-593-9067 Location: Silver Spring, MD Baud Rate: Up To 9600bps Sysop: Joe Kasser (W3/G3ZCZ)

The WireNet BBS Phone: 205-444-9638 Location: Birmingham, Alabama Baud Rate: Up To 14,400bps Sysop: Dennis Dease (N4NR)

Top of The Rock BBS Phone: 404-921-8687 Location: Lilburn, GA Baud Rate: Up To 14,400bps Sysop: Steve Driggs (KB4ZTN)

USS Enterprise 1701-D BBS Phone: 717-752-1468 Location: Berwick, PA Baud Rate: Up To 2400bps Sysop: Bill Barnes (N3JIX)

If you run a BBS and would like to join The AMSAT BBS Network, we want to hear from you. Tell us the name of your BBS, phone number, location (city, state), baud rate, sysop's name and callsign, and Internet and/or CompuServe address. Also, what AMSAT, ARRL, etc. files do you post each week? Send your information to John Wisniowski, N6DBF via Internet at n6dbf@amsat.org or on Compuserve at 70233,75.

Western Pacific Database BBS Offers a Different Approach

The Western Pacific Satellite Database, run by Daniel C. Dufficy, KH8AF, came on line in 1988 to provide updated Element Sets for Polar Orbiting Weather Satellites to an original group of 6 users in the Pacific Rim. By 1990 the User Base had expanded to a multitude of Australian and New Zealand Amateurs. They found it easier to dial direct during their evening hours, over the new fiber-optic cables spanning the Pacific, which supported fast modems at incredibly cheap rates for 2 or 3 minutes of semi-monthly download time. The existence of this database in the local California backyard was a well kept secret until 1992 when it was published in a Weather Satellite Handbook. Today, there are over 200 users stateside, but the lines are almost always open. The average download takes only 3 minutes or less. The Database runs on a 486 based system and accepts anything up to 14,400 baud (V32.bis), with most standard protocols.

The secret to having phone lines that are virtually always free is that the BBS only has 4 available files. These are a file of ANS bulletins, one containing TLE Keps, an IT.ORB kep file, and Space News). No other functions are available, (i.e. uploading, e-mail, etc.). Thus connect time is kept to a minimum. This makes the system available to more users at any given time.

New Software Available from AMSAT: UPDOWN-A

UpDown, an Amateur Radio Satellite Frequency Program has been completely rewritten and is now available from AMSAT for a cost of $15. This is a program that graphically displays all the frequncies, modes, and histories of all currently flying amateur radio satellites including KO-25, IO-26, AO-27, PO-28 etc. The new version is called UPDOWN-A. This is a self extracting file, that produces three versions of satellite frequency programs called UpDown2, UpDnWin1, and MinUpDn1.

UpDown2 runs under DOS and is useful for laptop operation, UpDnWin1 is a full screen, more capable, program and runs under Windows, and MinUpDn1 is a smaller Windows version to enable the concurrent display of other programs. With MinUpDn1, it is possible to display both a tracking program like InstantTrack and a Frequncy Program.

New features of UpDown include:

1. Being able to dynamically display Up and Down Link Frequencies and adjust for Doppler effect.

2. Being able to add notes to the existing text files on each satellite.

3. Simple point-and-click operation.

New AMSAT QSL Bureau Manager

The AMSAT QSL Bureau has a new manager. He is

Walt Rader WA3DMF 3702 Allison St.
Brentwood, MD 20722

For a number of years, Walt has handled orders for AMSAT callsign badges, so he is no stranger to our volunteer corps. Walt takes over this position from Perry Yantis, WB8OTH, who ran the QSL Bureau for many many years. If you are active on the satellites and do not have an SASE on file with Walt, you should.

Clementine

Recent images of the Moon taken by the Clementine spacecraft are available by ftp and email. If you have anonymous ftp access, ftp to clementine.s1.gov [128.15.32.9]. For email access, send a message to ftpmail@clementine.s1.gov with no subject and text of "help" only. Binary files such as GIF images are uuencoded and split into 60k segments for mailing.

ARRL Info Server

The ARRL maintains an e-mail server with many text files about amateur radio. Send a message to info@arrl.org with no subject and text of "help" only.

Local Meetings

Local gatherings of AMSAT enthusiasts can be an excellent way to promote the amateur radio space program. The group in the Washington, DC area has met several times in the last three years. The most recent meeting was organized by Pat Kilroy WD8LAQ and held at the NASA Goddard Space Flight Center in January. The meeting featured presentations and demonstrations by Tom Clark W3IWI, Bob Bruninga WB4APR, Eric Rosenberg WD3Q, and many others. Steve Greene KA1LM is organizing a forum for beginners in April.

If you are sponsoring a local or regional AMSAT meeting please drop a note to the editor of the AMSAT Journal with full information.

1994 AMSAT Field Day Competition Announcement

Field Day is once again just around the corner on June 25th and 26th, and we are proud to announce the 1994 AMSAT Field Day competition. Last year's effort was very successful and we will be using the same special rules. The AMSAT competition is to encourage the use of all amateur satellites, including the digital satellites.

Here are the rules for the 1994 AMSAT Field Day competition.

1. ANALOG TRANSPONDERS

Each satellite is considered a separate band. All phone QSO's and all CW QSO's on a given satellite are considered separate bands. All packet/RTTY/ASCII/AMTOR QSO's are counted as CW QSO's. Phone QSO's count for one point and CW QSO's count for two points. Cross-mode contacts are not allowed. The use of more than one transmitter at the same time in a single band is prohibited.

2. DIGITAL TRANSPONDERS

Each satellite is considered a separate band. The following uploads/downloads each count as a CW contact (two points):

(a) Upload of a Satellite Field Day Greetings file. (b) Download of Satellite Field Day Greetings files posted by other stations.

Satellite digipeat QSO's do not count for any score. The use of gateway stations to uplink/downlink is not allowed.

SAMPLE SATELLITE FIELD DAY GREETINGS FILE:

"Greetings from WA5ZIB Field Day Satellite station near Galveston, Texas with 24 participating members. All the best and 73!"

3. OPERATING CLASS

Stations supplied only with emergency power are in a separate operating class from those that utilize commercial power.

The Satellite Summary Sheet shown below should be used for submittal of the AMSAT Field Day competition results to Andy MacAllister WA5ZIB, Vice President User Services, 14714 Knights Way Drive, Houston, TX 77083-5640. Deadline for submissions is August 1, 1994.

Competition was tough in 1993 and should be even tougher in 1994. We hope this competition provides satellite operators with the practice necessary to be able to set up a ground station and effectively operate the satellites in an emergency situation. Remember that Field Day also provides a good opportunity to give some newcomers a chance at operating the satellites. Most of all, it should be a lot of fun for all who participate.

GOOD LUCK ON FD

Satellite Summary Sheet - 1994

Satellite	CW		Phone
	x 2	x 1	
Totals			

Your Field Day Callsign ____________

Field Day Classification ____________

Power Source(s) ____________

Your name and home call ____________

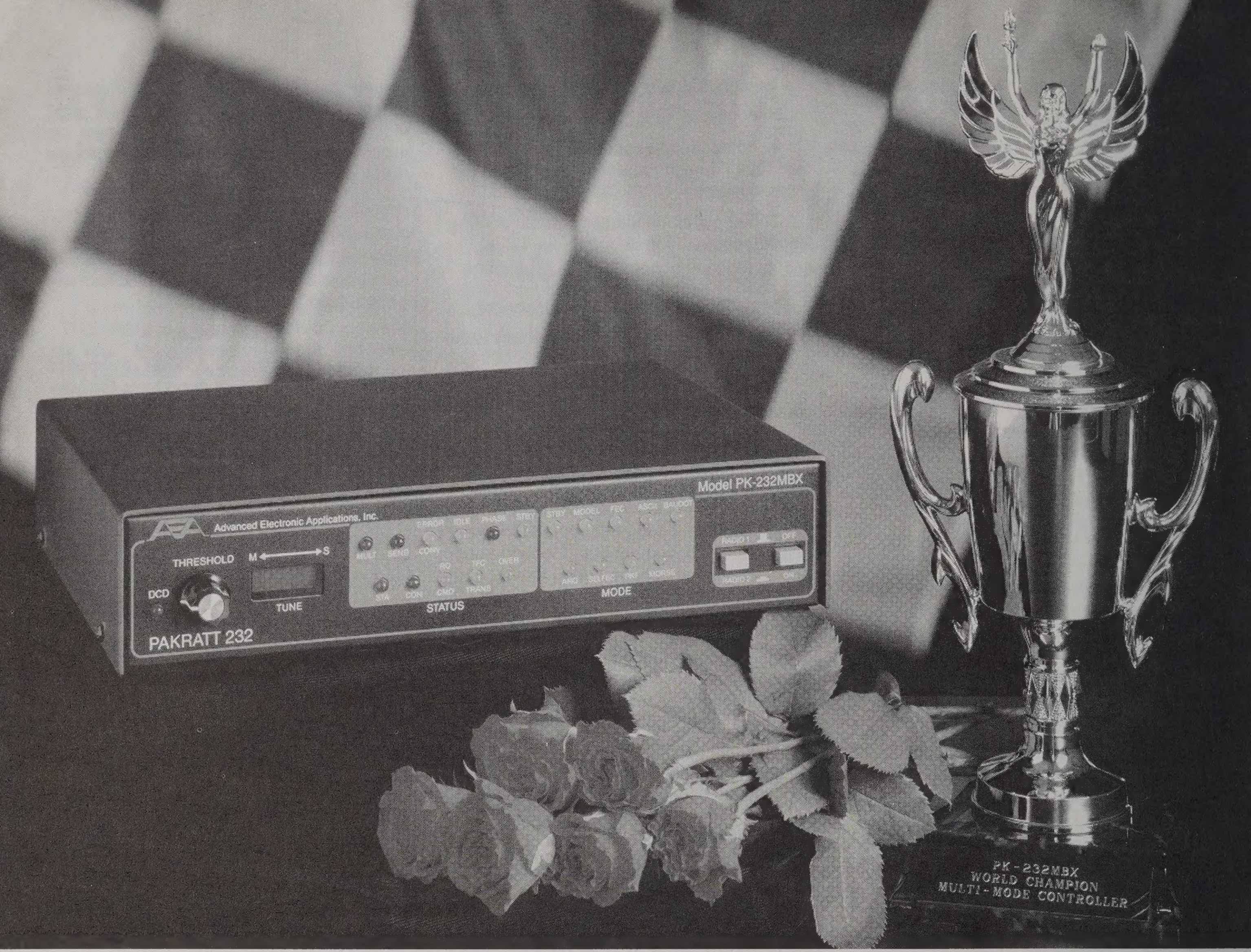
Home address ____________

____

Comments ____________

____

____



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